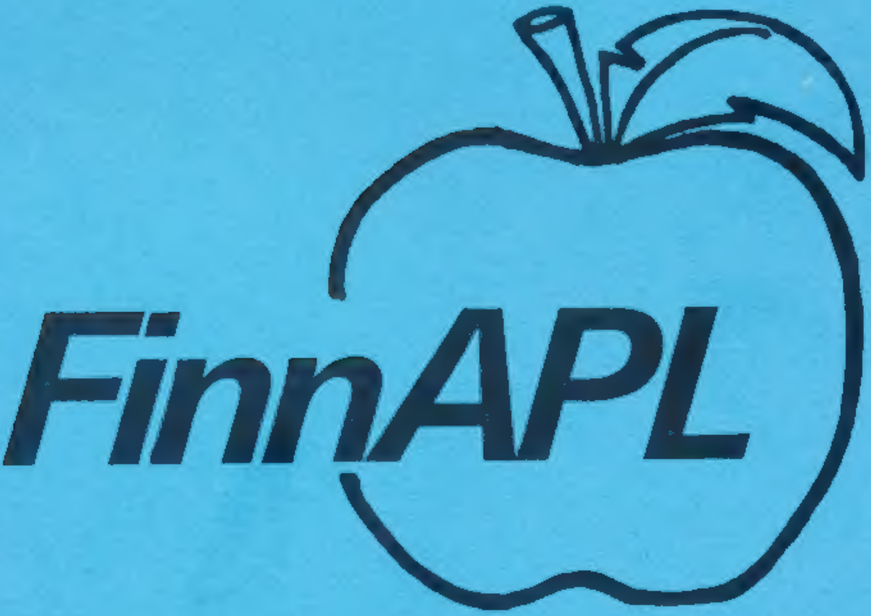
FINNISH APL ASSOCIATION

FINNAPL IDIOM LIBRARY

SECOND EDITION

Jul. 13, 1982



Helsinki 1982

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FOREWORD OF FIRST EDITION

The publication of this APL idiom collection was initiated by the FinnAPL Working Group of Programming Techniques in spring 1981, when good ways of teaching and promoting efficient use of APL were being discussed. It is a widely known fact that some idiom containing booklets and APL workspaces exist. However, the working group discovered several deficiencies in the usefulness of these sources: difficult and slow access, the relatively small amount of idioms and the lack of appropriate search methods. These arguments led to the decision of building a versatile, easy-to-use idiom library, from which any APL user can find practical tools for daily work. The goal of this publication is to promote good and efficient APL usage by means of APL idioms, and facilitate and speed up APL programming.

The first and most important source of idioms has been the Working Group itself - the experience and everybody's own idiom reservoirs. The members of the group are:

Arto Juvonen	TMT-Team
Seppo Kaltio	TMT-Team
Timo Kunnas	Helsinki University of Technology
Timo Laurmaa	Bank of Helsinki
Hannu Lehto	Datema
Heimo Penttinen	Finnish Broadcasting Company
Tauno Ylinen	Ministry of Finance

Also the following publications were very useful:

A.J. Perlis, S. Rugaber:
Programming with Idioms in APL,
APL Quote Quad, vol. 9, no. 4, 1979
K.E. Iverson:
Notation as a Tool of Thought
Communications of the ACM, vol. 23, no. 8, August 1980
O.I. Franksen:
Computing - An Economy of Thought
NordDATA81, Copenhagen 1981
R.P. Polivka, S. Pakin:
APL: The Language and Its Usage
Prentice-Hall, 1975
R.A. Smith
A Programming Technique for Non-rectangular Data, APL79 Conference Proceedings, ACM.

The Finnish APL Association is pleased to receive any comments and new idioms in order to increase the versatility and quality of this idiom library.

FOREWORD OF SECOND EDITION

The second edition of the FinnAPL Idiom Library differs from the first one in several aspects: the number of idioms has been increased from 452 to 631, most of the idioms have been tested with a computer, many errors have been corrected, some explanations have been made easier to understand, and a function-based index has been included. The publication is also introduced in a more compact version (FinnAPL Pocket Idiom Library).

The working group for this edition has been:

Akif Ali	Helsinki University of Technology
Timo Kunnas	Helsinki University of Technology
Timo Laurmaa	Bank of Helsinki

FinnAPL wishes to thank for the numerous contributions by APL users from several countries, and is still pleased to receive comments and new idioms to help in developing future editions of the library.

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THE USE OF IDIOMS IN APL

Arto Juvonen
TMT-Team

1. INTRODUCTION

Idiom is a speech form that is peculiar within the usage of a given language. In APL, an idiom is a meaningful primitive structure constructed from primitive functions. Idiom is characterized by ease of recognition, frequency of occurrence and flexibility in use. Due to APL's conciseness and functional nature the language contains a large number of useful idioms, whose familiarity makes the programming effort more efficient and unravels programs made by others.

An idiom is an APL primitive construct like the APL primitive and derived functions because of its presence in the language. However, an idiom has a special connotation, that cannot be directly derived from its constituents. Once the idiom is learned, the meaning can be perceived from the program line without analyzing the structure function by function. Let us take as an example the 'if'-idiom ⌈⍳ in a conditional branch statement. Due to the expression →LINE⌈⍳COND the program branches to line LINE, if COND (1 or 0) is true. Otherwise execution continues at the next line. The expression might be difficult to decipher, if the idiom is not familiar. After learning the behavior of the idiom the use and understanding of it is trivial.

One of the main characteristics of an idiom is its conciseness. It is easy to remember and recognize and quick to type. Because of this it is not necessary to define an idiom as a function, although this is quite common. Idioms are often more useful as part of another expression. By writing the idiom straight to the function line the naming problem can be avoided. A person acquainted with the idiom does not have to know in which workspace and with which name the expression is saved, and does not have to copy the function into the workspace. Also the problem of having a different object of the same name in the workspace can be avoided. Moreover, the reader of the program does not have to recognize the name. It is also useful to use idiomatic expressions in the library subroutines instead of the equivalent

defined functions to avoid chained calls and thus group definitions or copying of defined library functions one by one during the first application programming test run.

The difference between an idiom and a defined function can easily be seen. An important difference is their length. Idioms are almost always expressed naturally in one line. A defined function may contain more complicated, e.g. iterative structures. If an idiom is embedded in a defined function, it is useful to write it in a general form to allow wider use. Thus in a defined function the idiom is hidden in the jungle of shape and reshape functions that guarantee the compatibility of the arguments. If the idiom is written as part of the function line, the simplest form according to the current arguments can be used. There are also idioms that cannot be written as a function because of the great number of arguments or some other special feature. Such idioms are e.g. templates, that can be used to create new idioms.

2. THE USE OF IDIOMS IN WRITING AND READING PROGRAMS

No language contains a perfect set of functions for every need encountered in solving problems. APL idioms can often be used as APL primitive functions. They make the language more expressive and bring the language nearer to the human thought structures. Idioms act as an intermediate language in man-machine communication. Thus, mastering a group of basic idioms is necessary for efficient APL programming allowing the lines to be written from left to right and not a function at a time from right to left.

Idioms act also as a means of convaying thougths between the program writer and the reader. Understanding a program is a discontinuous process. The meaning of a line is first unclear. After initial research the reader can make a hypothesis of the meaning. Additional studying verifies the model. Insight is more easily attained if the program writer and reader share a large number of idioms. Not knowing the idiom written by someone else interrupts understanding of the program flow. The reader can study the result of functions applied to sample arrays element by element, but making a hypothesis of the meaning of the expression may be very difficult.

Thus both in writing and reading programs

mastering a large set of idioms is an invaluable tool. Idioms should be learned early while learning other language fundamentals, as this helps to organize the students understanding of the numerous possibilities of the primitive functions and their combinations. Idioms are best learned by encountering them in different environments and by using them. New idioms can be found by using one-line solutions, as this helps avoiding splitting of data and thought.

3. EXAMPLES OF IDIOMS

Idioms can be classified for example in the following manner:

1. Structural
2. Sorting
3. Searching
4. Tests
5. Forming boolean vectors
6. Text processing
7. Numerical
8. Object generators
9. Subvector processing
10. Templates

Changing the structure of an array is common because of the compatibility requirements of functions. A typical example is forming a vector into a one line matrix V←(1,⍴V)⍴V or a 'column vector' V←⍉(1,⍴V)⍴V. A numeric vector can be reshaped also with the idiom V←V∘.+,0. Often operating with higher dimensional arrays may be cumbersome. E.g. multiplying an array A of shape k,m,n with array B of shape k,m,l,n so that the elements along the second axis of A are also used for multiplying the elements along the third axis of B necessitates forming a new axis in A after the second axis. The new axis is first shaped to contain a dimension of length one. The dimension is replicated l times by indexing:
S←(1,⍴A)[2 3 1 4]⍴A and S←S[;;(⍴B)[3]⍴1;]. An array is restructured often by the transpose function T⍉A. The element T[I] specifies, where the i:th axis of the argument array will be located in the resulting array. Thus forming a new axis after the i:th axis and replicating it n times can be generally stated with the idiom (⍋⍋(I+1),⍳⍴⍴A)⍉(N,⍴A)⍴A.

Sorting arrays is based on the grade primitive function ⍋. The task of idioms is to create suitable numeric arguments for the grade function.

For example a word list can be sorted with the idiom I←⍋(⍴A)⊥⍉A⍳M, where A contains the alphabet used and M the words to be sorted. By using this idiom a sorting of 8 to 10 columns can be performed at a time. Sorting a wider matrix or taking other factors into consideration requires sorting to be started with the least significant sorting factor and indexing the next factor with the resulting grade vector. E.g. forming the grade vector I by using the first two columns of a numeric matrix M would be performed by using first the second column I←⍋M[;2] and then the first one I←I[⍋M[I;1]].

Often we have to sort numeric codes in vector A to the corresponding sequence S e.g. for summing. The required grade vector can be formed with the idiom I←⍋S⍳A. A[I] can be used to get the lengths of the subvectors to be summed.

Searching is often based on location function (⍳) or compression of indices L/⍳⍴L. The location function can be used e.g. to locate the index of the first positive element in vector V: (V>0)⍳1 or the index of the first occurrence of vector A in matrix M: (M∧.=A)⍳1.

Test idioms are very frequent. Good examples are the test of numericity of an array A: 0∊0\0⍴A, and the test of emptiness: 0∊⍴A, and the test of equalness of all elements in vector A: ∧/A=1↑A.

Forming a modification of a logical vector is often fundamental when using the APL way of solving problems. E.g. the following transformations can be performed to a logical vector (array):

```
Turn on all 0's after the first 1
L←                        0 0 1 0 1 0 1
∨\L                       0 0 1 1 1 1 1

Leave on the 1's preceding the first 0
L←                        1 1 1 0 1 0 1
∧\L                       1 1 1 0 0 0 0

Leave on only the first 1
L←                        0 0 1 0 1 1 1
<\L                       0 0 1 0 0 0 0

Create a vector of running even parity
L←                        1 0 0 1 1 0 1
≠\L                       1 1 1 0 1 1 0
```

```
Leave on the first 1 on each group of 1's
L←                          0 1 1 0 1 1 1
L>¯1↓0,L                    0 1 0 0 1 0 0
Generally L>((-⍴⍴L)↑¯1)↓0,L

Leave on the first group of 1's
L←                          0 1 1 0 1 1 0
L∧∧\L=∨\L                   0 1 1 0 0 0 0

Leave on the groups  of 1 in B  indicated  by
the corresponding 1 in vector L
L←                          0 1 0 0 0 0 1 0 1
B←                          1 1 1 0 1 1 0 1 1
B∧A∊(L∧B)/A←+\B>¯1↓0,B      1 1 1 0 0 0 0 1 1
```

Text processing often aims at finding a character or a character string satisfying given conditions. Because APL primitive functions use a character as an element, the text and word processing area contains many idioms to perform higher level operations. Some examples are deletion of blanks from a character vector V: `(V≠' ')/V`, deleting leading blanks `(∨\V≠' ')/V` and trailing blanks: `(¯1↑(V≠' ')/⍳⍴V)/V`. Replacing each element A in vector V with B: `V[(V=A)/⍳⍴V]←B` is simple, and the idiom `V[L/⍳⍴L]←B[(L←I≤⍴A)/I←A⍳V]` can be used, if A and B are vectors. The occurrences of vector A in vector V can be located with the idiom
`I←(V[I∘.+¯1+⍳⍴A]∧.=A)/I←(I=1↑A)/⍳⍴I←(1-⍴A)↓V`.
In it the possible starting locations are found by the initial letter and the length of A. The substrings of V starting from these indices are compared with A.

Vectors are often the most convenient way to handle data because of flexible selection and indexing. A vector is often divided into variable length parts (subvectors) that must be operated on analogously. In the following examples a boolean vector P indicates the partitioning of the argument vector.

```
P←1 0 0 0  1 0  1
A←1 2 3 4  5 6  7  and  L←1 1 0 1  0 0  1

The lengths of the parts
Z←Z-¯1↓0,Z←(1⌽P)/⍳⍴P      4 2 1

The sum of the elements of parts in A
Z←Z-¯1↓0,Z←(1⌽P)/+\A      10 11 7

The or-reduction of the parts in vector L
Z←(P/L)≥Z/1⌽Z←(P∨L)/P     1 0 1
```

A template is a model that can be used to create useful structures. In the following templates `⍺` stands for a suitable function or another idiom. Template `(⍴A)⍴⍺,A` means raveling array A, operating on it and reshaping it back to the original shape. By using this template and a suitable idiom we can e.g. change the elements A in array S to B: `V[(V=A)/⍳⍴V←,S]←B` and `S←(⍴S)⍴V`.

Using numerical calculation instead of conditional branching is often useful. E.g. idiom `(X×B)+Y×~B` can be used to select an element from X if the corresponding element in B is true, otherwise from Y. The Idiom `X*1 ¯1[B+1]` can be used to negate the elements of X indicated by B.

The template `A⍉B∘.⍺C` encourages to use outer product to compute all needed combinations and to select the needed ones with the diagonal transpose... For example adding the vector X to the columns of matrix M can be performed with the idiom `1 1 2⍉X∘.+M`.

HOW TO USE THIS IDIOM LIBRARY

Timo Laurmaa
Bank of Helsinki

1. THE PARTS OF THE IDIOM LIBRARY

1.1 Idiom list

The library is based on an idiom list containing 631 APL idioms. Every idiom consists of an APL expression, a brief verbal description, the description of arguments and parameters, and an index number. The list is sorted in a 'functionally alphabetical' order; therefore two very similar idioms will not be far from each other. The functionally alphabetical order is based on the order of functions listed in the Table of Functions so that e.g. expressions containing ⍋ are found in the beginning of the list and so on.

The argument description states the requirements set to the variables in the expression (arguments or parameters). The most common requirements include information of the rank or shape of the array as well as the type, according to the following rules:

- Naming convention of data objects:
  -- X,Y arguments
  -- G,H parameters
  -- A,B intermediate results etc.
- Data type expressions (in argument descriptions):
  -- C = character
  -- B = logical (boolean)
  -- I = integer
  -- D = any numeric data type
  -- A = any data type, no limitations
- Representation of the ranks of arrays:
  -- 0 = scalar
  -- 1 = vector
  2 = matrix
  -- = (empty) no limitations; the shape is mentioned separately, if necessary
- Examples
  -- X←D2 argument X is a numeric matrix
  -- G←I0 parameter G is an integer scalar

1.2 Permuted index

The bulk of this idiom library consists of an alphabetical index sorted according to a so-called permuted index (keyword in context) method. This method is used in order to facilitate finding appropriate idioms with the assistance of typical keywords. A verbal description with n words will usually occur in n places in the index, at the place of each word of the description. This provides an easy way to find a suitable idiom even if its description is not completely known. The index contains a reference to the index numbers in the idiom list. If a description corresponds to two idioms with numbers clearly unequal, it is likely that the desired result can be achieved with two highly different solutions (nearly equal numbers would indicate similarly built expressions).

1.3 Synonym list

Same results can be achieved in several different ways in APL. This list is a collection of certain idioms from the idiom list that perform (at least approximately) similar operations. (They may differ from each other for instance by requirements set for their arguments.) The synonym list gives a good insight of how to produce similar results in many different ways in APL. Studying these differences will certainly help widening the understanding of APL idioms and expressions.

2. LIMITATIONS OF THE IDIOM LIBRARY

APL idiom library has been designed for the most common programming circumstances. Consequently, some idioms will not work as desired in every special situations. The idioms will generally work with at least the default values of a VS APL empty workspace, which usually apply also in application workspaces. Possible circumstances for unexpected behaviour of certain idioms might be for instance

- ⎕PP←4 Printing precision is small
- ⎕CT←0.1 Comparison tolerance in high

The index origin ⎕IO deserves special consideration. As the default value is one, every idiom (unless the desription states differently) will work if ⎕IO = 1. Several idioms include ⎕IO in the APL expression, which means that the idiom works with both possible ⎕IO values. Exception

cases (works only if ⎕IO = 0) are reported separately in the verbal description. The great majority of the idioms will work in the expected way, independent of parameter values.

This publication intends to present only efficient idioms that promote good APL programming style. It is, however, sometimes difficult to decide if an APL expression will be efficient in every situation. Therefore, especially in handling very large data objects there is a danger that huge amounts of cpu time will be spent or that a WS FULL occurs unexpectedly. If the idiom is good in principle ((X⍳X)=⍳⍴X is a typical example), but in some conditions may turn out to be inefficient, this is mentioned in the verbal description. Avoiding WS FULL problem is possible for instance with the thumb rule stating that the outer product ∘. may easily cause a WS FULL if large data objects are being handled.

Some idioms include numeric or character constants which make the idioms more recognizable but seem to reduce their generality. For instance, the idiom DIVIDING A 400×12 CHARACTER MATRIX INTO ONE PAGE contains the constants 400 and 12, which clearly have to be modified according to the column width and page length.

Certain idioms contain the delta function ∆ needed when chaining expressions. If these idioms are used, the workspace should contain this function defined in the following way:

```
      ∇Z←A ∆ B
  [1]   Z←A
      ∇
```

This function causes the rightmost expression to be processed first. The leftmost expression will then be executed independently of the result of the previous one.

3. EXAMPLES OF THE USE OF THE IDIOM LIBRARY

3.1 Finding an idiom to perform a desired task

If we want to use the idiom library to find an expression that underlines a text vector, we can examine words UNDERLINE, TEXT and VECTOR in the index. If the desired idiom belongs to the library, some of these key words will very likely be found in the index. As related idioms are described as UNDERLINING A STRING and UNDERLINING

WORDS, key word UNDERLINING will show where a suitable idiom can be found.

3.2 How can decode ⊤ be used

Because the idiom list is sorted according to a functional order, most idioms using ⊤ are grouped in the same part of the list, near its beginning. Studying idioms in this way will help learning new ways of applying APL functions and thus widen the APL way of thinking.

3.3 Removing duplicate lines or elements

The index part contains several idioms under the keyword DUPLICATE. These idioms have been collected to the synonym list. By comparing these idioms it is possible to find an expression that will work properly and efficiently in the desired situation, like finding different words from a word matrix.

3.4 What does expression A∘.+,0 do

Idioms based on the outer product can easily be found in the idiom list. The verbal description of idiom X∘.+,0 shows that this is a way to form a one-column matrix from a vector.

TABLE OF FUNCTIONS

1 ... 37 GRADE UP ⍋
38 ... 44 GRADE DOWN ⍒
45 ... 63 ENCODE ⊤
64 ... 84 DECODE ⊥
85 ... 101 EXECUTE ⍎
102 ... 111 FORMAT ⍕
112 ... 120 BRANCH →
121 ... 123 ROLL / DEAL ?
124 ... 128 MATRIX INVERSION / MATRIX DIVISION ⌹
129 ... 134 GEOMETRICAL ○
135 ... 142 FACTORIAL / BINOMIAL !
143 ... 204 OUTER PRODUCT ∘.ω
205 ... 246 INNER PRODUCT α.ω
247 ... 310 SCAN ω\ ω⍀
311 ... 374 REDUCTION ω/ ω⌿
375 ... 412 TAKE ↑
413 ... 448 DROP ↓
449 ... 449 CEILING / MAXIMUM ⌈
450 ... 462 FLOOR / MINIMUM ⌊
463 ... 479 MAGNITUDE / RESIDUE |
480 ... 490 EXPAND \
491 ... 513 COMPRESS /
514 ... 527 TRANSPOSE ⍉
528 ... 537 REVERSE / ROTATE ⌽ ⊖
538 ... 548 MEMBER OF ∊
549 ... 563 INDEX GENERATOR / INDEX OF ⍳
564 ... 569 LOGICAL ~ ∨ ∧ ⍱ ⍲
570 ... 575 COMPARISON < ≤ = ≥ > ≠
576 ... 598 RAVEL / CATENATE ,
599 ... 609 AXIS / INDEXING [
610 ... 618 SHAPE / RESHAPE ⍴
619 ... 628 ARITHMETIC + - × ÷
629 ... 631 MISCELLANEOUS

IDIOM LIST

```
---
    GRADE UP  ⍋

 1  ⌊.5×(⍋⍋X)+⌽⍋⍋⌽X                                          X←D1
    Ascending cardinal numbers (ranking, shareable)

 2  Y[A⍳⌈\A←⍋A[⍋(+\X)[A←⍋Y]]]                            X←B1; Y←D1
    Maximum scan (⌈\) over subvectors of Y indicated by X

 3  Y[A⍳⌈\A←⍋A[⍋(+\X)[A←⍒Y]]]                            X←B1; Y←D1
    Minimum scan (⌊\) over subvectors of Y indicated by X

 4  Y[⍋Y]∧.=X[⍋X]                                        X←D1; Y←D1
    Test if X and Y are permutations of each other

 5  X[A[⍋(+\(⍳ρX)∊+\⎕IO,Y)[A←⍋X]]]          X←D1; Y←I1; (ρX) ↔ +/Y
    Sorting subvectors of lengths Y

 6  Y[A[X/⍋(+\X)[A←⍋Y]]]                                 X←B1; Y←D1
    Minima (⌊/) of elements of subvectors of Y indicated by X

 7  A[⍋(+\X)[A←⍋Y]]                                      X←B1; Y←D1
    Grading up subvectors of Y indicated by X

 8  (ρX)ρ(,X)[⎕IO+A[⍋⌊A÷¯1↑ρX]]  Δ  A←(⍋,X)-⎕IO                X←D2
    Sorting rows of matrix X into ascending order

 9  (ρX)ρ(,X)[A[⍋(,⍉(⌽ρX)ρ⍳1↑ρX)[A←⍋,X]]]                      X←D2
    Sorting rows of matrix X into ascending order

10  (⍋⍋(G+1),⍳ρρX)⍉(Y,ρX)ρX                       G←I0; Y←I0; X←A
    Adding a new dimension after dimension G Y-fold

11  (Y,X,Z,...)[⍋⍋G]                X←A1; Y←A1; Z←A1; ... ; G←I1
    Merging X, Y, Z ... under control of G (mesh)

12  (X,Y)[⍋⍋G]                                X←A1; Y←A1; G←B1
    Merging X and Y under control of G (mesh)

13  ⍋⍋X                                                      X←D1
    Ascending cardinal numbers (ranking, all different)

14  Y[A[X/⍋(+\X)[A←⍒Y]]]                                 X←B1; Y←D1
    Maxima (⌈/) of elements of subvectors of Y indicated by X

15  A[⍋(+\X)[A←⍒Y]]                                      X←B1; Y←D1
    Grading down subvectors of Y indicated by X

16  (Y,X)[⍋⍒G]                                X←A1; Y←A1; G←B1
    Merging X and Y under control of G (mesh)

17  ⍋⍒X                                                      X←D1
    Descending cardinal numbers (ranking, all different)
```

```
18  X[⍋(1+⍴Y)⊥Y⍳⍉X;]                               X←A2; Y←A1
    Sorting rows of X according to key Y (alphabetizing)

19  X[⍋+⌿A<.-⍉A←X,0;]                                     X←D2
    Sorting a matrix into lexicographic order

20  X[⍋X]∧.=⍳⍴X                                           X←I1
    Test if X is a permutation vector

21  Y[⍋X++\X]                                       X←B1; Y←A1
    Rotate first elements (1⌽) of subvectors of Y indicated by X

22  1↑⍋X                                                  X←D1
    Index of (first) minimum element of X

23  ¯1↑⍋X                                                 X←D1
    Index of (first) maximum element of X

24  X[(⍋X)[⌈.5×⍴X]]                                       X←D1
    Median

25  (X,'''')[(⎕IO+⍴X)⌊⍋(⍳⍴X),(''''=X)/⍳⍴X]                 X←C1
    Doubling quotes (for execution)

26  (X,'*')[(⎕IO+⍴X)⌊⍋(⍳⍴X),(Y×⍴G)⍴G]           X←C1; Y←I0; G←I1
    Inserting Y *'s  into vector X after indices G

27  (⍴X)≥⍋(⍳⍴X),Y                                    X←D1; Y←I1
    Expansion vector with zero after indices Y

28  (X,A⍴H)[⍋(⍳⍴X),A⍴Y] Δ A←G×⍴,Y         X←A1; Y←I1; G←I0; H←A0
    Catenating G elements H after indices Y in vector X

29  ((A⍴H),X)[⍋(A⍴Y),⍳⍴X] Δ A←G×⍴,Y       X←A1; Y←I1; G←I0; H←A0
    Catenating G elements H before indices Y in vector X

30  ⍋Y⍳X                                              Y←A1; X←A1
    Grade up according to key Y

31  A Δ A[⍋G]←A←Y,X                             X←A1; Y←A1; G←B1
    Merging X and Y under control of G (mesh)

32  X[⍋Y[X]]                                          X←I1; Y←D1
    Sorting indices X according to data Y

33  X[⍋X[;Y];]                                            X←D2
    Sorting a matrix according to Y:th column

34  ⍋X×¯1 1[Y]                                        X←D1; Y←I0
    Choosing sorting direction during execution

35  X[⍋X]                                                 X←D1
    Sorting X into ascending order
```

36 `Y[⍋X]` X←A1; Y←A1
Sorting Y according to X

37 `⍋X` X←I1
Inverting a permutation

GRADE DOWN ⍒

38 `X[⍒+⌿A<.-⍉A←X,0;]` X←D2
Sorting a matrix into reverse lexicographic order

39 `X[⌽⍒+\(⍳⍴X)∊+\⎕IO,Y]` X←D1; Y←I1
Reversal (⌽) of subvectors having lengths Y

40 `Y[⌽⍒+\X]` X←B1; Y←A1
Reversal (⌽) of subvectors starting at indices X

41 `(+/X)↑⍒X` X←B1
Indices of ones in logical vector X

42 `X[⍒' '≠X]` X←C1
Moving all blanks to end of text

43 `X[⍒Y]` X←A1; Y←B1
Moving elements satisfying condition Y to the start of X

44 `X[⍒X]` X←D1
Sorting X into descending order

ENCODE ⊤

45 `⍕10⊥((1+⌈2⍟⌈/,X)⍴2)⊤X` X←I0
Binary format of decimal number X

46 `1 0⍕10 10⊤1-⎕IO-⍳X` X←I0
Helps locating column positions 1..X

47 `⌽((0,⍳⍴X)∘.=+⌿~A)+.×(-X)×.*A←((⍴X)⍴2)⊤¯1+⍳2*⍴X` X←D1
Polynomial with roots X

48 `⎕IO+(⍴X)⊤-⎕IO-(,(X=(⍴X)⍴⌈⌿X)∧X=⍉(⌽⍴X)⍴⌊/X)/⍳×/⍴X` X←D2
Index pairs of saddle points

49 `⍉'0123456789ABCDEF'[⎕IO+((⌈⌈/16⍟,X)⍴16)⊤X]` X←I
Conversion from decimal to hexadecimal

50 `(,X)/1+A⊤¯1+⍳×/A←⍴X` X←C2
Transforming connectivity matrix X into a connectivity list

51 `⎕IO+(⍴X)⊤(⍳×/⍴X)-⎕IO` X←A
Matrix of all indices of X

```
52  ((⌈2⍟1+X)⍴2)⊤0,⍳X                                        X←I0
```
All binary representations up to X (truth table)

```
53  ((1+⌊10⍟X)⍴10)⊤X                                         X←I0
```
Digits of X separately

```
54  ((1+⌊Y⍟X)⍴Y)⊤X                                   X←D0; Y←D0
```
Representation of X in base Y

```
55  ⎕IO+(⍴X)⊤(-⎕IO)+(,X∊Y)/⍳⍴,X                        X←A; Y←A
```
Indices of elements Y in array X

```
56  ,' ',⍉'0123456789ABCDEF'[⎕IO+16 16⊤-⎕IO-⎕AV⍳X]          X←C1
```
Conversion of characters to hexadecimal representation (⎕AV)

```
57  ⍉(3⍴100)⊤X                                                X←D
```
Separating a date YYMMDD to YY, MM, DD

```
58  ⎕IO+(X,Y)⊤(⍳X×Y)-⎕IO                             X←I0; Y←I0
```
All pairs of elements of ⍳X and ⍳Y

```
59  ((⍴X)⍴2)⊤¯1+⍳2*⍴X                                        X←A1
```
Matrix for choosing all subsets of X (truth table)

```
60  (X⍴2)⊤¯1+⍳2*X                                            X←I0
```
All binary representations with X bits (truth table)

```
61  1+Y⊤X                                             X←D; Y←D0
```
Incrementing cyclic counter X with upper limit Y

```
62  0 1⊤X                                                     X←D
```
Integer and fractional parts of positive numbers

```
63  10 100 1000⊤X                                             X←I
```
Decoding numeric code ABBCCC into a matrix

DECODE ⊥

```
64  A Δ A[3 6]←':' Δ A←⍕1000⊥3↑3↓⎕TS
```
Representation of current time (24 hour clock)

```
65  A Δ A[5 8]←'-' Δ A←⍕1000⊥3↑⎕TS
```
Representation of current date (descending format)

```
66  →Y[1+2⊥X]                                        Y←I1; X←B1
```
Case structure with an encoded branch destination

```
67  G⊥Y⌹X∘.*⌽-⎕IO-⍳⍴X                       X←D1; Y←D1; G←D0
```
Interpolated value of series (X,Y) at G

```
68  ' *○⍟'[⎕IO+2⊥X∘.≥⍳⌈/,X]                    X←I2; 1⍴⍴X ↔ 2
```
Barchart of two integer series (across the page)

69 `(X∘.+,0)⊥Y` X←D1; Y←D1
Value of polynomial with coefficients Y at points X

70 `((A⍳A)=⍳⍴A←2⊥X∧.=⍉X)⌿X` X←A2
Removing duplicate rows

71 `B⍴A ⋄ A[⎕IO+B[1]⊥-⎕IO-X]←1 ⋄ A←(×/B←0 0+⌈/,X)⍴0` X←C2
Transforming connectivity list X into a connectivity matrix

72 `100⊥100|3↑⎕TS`
Encoding current date

73 `(1-(' '=X)⊥1)↓X` X←C1
Removing trailing blanks

74 `(12⍴7⍴31 30)[X]-0⌈¯1+2⊥(X=2),[.1]0≠4|Y` X←I0; Y←I
Number of days in month X of year Y

75 `16⊥-⎕IO-'0123456789ABCDEF'⍳⍉X` X←C
Conversion from hexadecimal to decimal

76 `(1-(' '=X)⊥1)⌽X` X←C
Justifying right

77 `(÷1+Y÷100)⊥⌽X` X←D1; Y←D0
Present value of cash flows X at interest rate Y %

78 `10⊥¯1+'0123456789'⍳X` X←C1
Transformation of alphanumeric string into numeric

79 `(' '=X)⊥1` X←C1
Index of first non-blank, counted from the rear

80 `(,X)[⎕IO+(⍴X)⊥Y-⎕IO]` X←A; Y←I2
Indexing scattered elements

81 `⎕IO+(⍴X)⊥Y-⎕IO` X←A; Y←I2
Conversion of indices to indices of raveled array

82 `(1+Y÷100)⊥X` X←D1; Y←D0
Future value of cash flows X at interest rate Y %

83 `X⊥Y` X←D0; Y←D
Value of polynomial with coefficients Y at point X

84 `2⊥X` X←B
Integer representation of logical vectors

EXECUTE ⍎

85 `⍎⍎'1','↑↓'[⎕IO+∧/(⍴X)=⌽⍴X],'''0~0∊X=-⍉X'''` X←D2
Test for antisymmetricity of matrix X

```
 86  ⍎⍎'1','↑↓'[⎕IO+∧/(ρX)=⌽ρX],'''0~0∊X=⍉X'''                   X←A2
     Test for symmetricity of matrix X

 87  ⌊10⍟(⍎('.'≠A)/A←⍕X)÷X                                       X←D1
     Number of decimals of elements of X

 88  ⍎'VAR',(⍕X),'←Y'                                      X←A0; Y←A
     Using a variable named according to X

 89  ⍎X/'→'                                                      X←L0
     Conditional branch out of programs

 90  ' *'[⎕IO+(⌽(¯1+⌊/A)+⍳1+(⌈/A)-⌊/A)∘.=A←⌊.5+⍎F]     F←A1; X←D1
     Graph of F(X) at points X ('X'∊F)

 91  A+.×⍎F,0ρX←Y[1]+(A←--/Y÷G)×0,⍳G    F←A1; G←D0; Y←D1; ρY ↔ 2
     Definite integral of F(X) in range Y with G steps ('X'∊F)

 92  X←⍎,((2↑'X'),' ',[.5]A)[⎕IO+~' '∧.=A←,⍞;]
     Changing X if a new input value is given

 93  (X∨.≠' ')\1↓⍎'0 ',,X,' '                                    X←C2
     Conversion of each row into a number (default zero)

 94  ⍎((X∧.=' ')/'Y'),X                                          X←D1
     Converting expression X to numeric form with default value Y

 95  1↓⍎'0 ',(∧/X∊' 0123456789')/X                               X←C1
     Test if numeric and converting into numeric form

 96  ⍎X/'EXPRESSION'                                             X←B0
     Conditional execution

 97  1ρ(⍎⍞,',⍳0'),X                                               X←D0
     Giving a numeric default value for input

 98  A←⍎,',','(','0','ρ',Y,'←',X,')'                      X←C2; Y←C2
     Assign values of expressions in X to variables named in Y

 99  ⍎,',','(',',',X,')'                                          X←A
     Evaluation of several expressions; results form a vector

100  ⍎'X[',((¯1+ρρX)ρ';'),'Y]'                              X←A; Y←I
     Indexing when rank is not known beforehand

101  ⍎,'+',X                                                     X←A2
     Sum of numbers in character matrix X

---
```

FORMAT ⍕

```
102  (3⌽7 0⍕X∘.+,0),⍕Y                                    X←D1; Y←A2
     Numeric headers (elements of X) for rows of table Y
```

```
103  ⍕X∘.+,0                                                 X←D1
     Formatting a numerical vector to run down the page

104  A Δ A[(' '=A)/⍳⍴A]←'.' Δ A←⍕⌽3↑⎕TS
     Representation of current date (ascending format)

105  (,(0 1↓3 0⍕100+3 1⍴12 0 0|3↑3↓⎕TS),':: '),'AP'[1+12≤⎕TS[4]],'M'
     Representation of current time (12 hour clock)

106  0 1↓(2↑Y+1)⍕(10*Y)+((⍴X),1)⍴X                     X←I1; Y←I0
     Leading zeroes for positive numbers X in fields of width Y

107  A Δ A[(' '=A)/⍳⍴A]←'/' Δ A←⍕100|1⌽3↑⎕TS
     Representation of current date (American)

108  (⍴A)⍴B\(B←,('0'≠A)∨' '≠¯1⌽A)/,A←' ',⍕X                   X←A
     Formatting with zero values replaced by blanks

109  ((1,G)×⍴X)⍴2 1 3⍉(⌽G,⍴X)⍴(,G,[1.1]Y)⍕⍉X      X←D2; Y←I1; G←I0
     Row-by-row formatting (width G) of X with Y decimals per row

110  (,G,[1.1]H)⍕X                                X←D; G←I1; H←I1
     Formatting X with H decimals in fields of width G

111  ⍴⍕X                                                     X←D0
     Number of digit positions in scalar X (depends on ⎕PP)

---
     BRANCH  →

112  →⎕LC⌈⍳∨/,(X←X∨X∨.∧X)≠+X                                X←B2
     Forming a transitive closure

113  →Y⌈⍳G≥X←X+1                                  X←I0; Y←I0; G←I0
     For-loop ending construct

114  →Y⌈⍳X                                               X←B0; Y←I0
     Conditional branch to line Y

115  →X/Y                                                 X←B1; Y←I1
     Case structure with logical switch (preferring from start)

116  →X⌽Y                                                 X←I0; Y←I1
     Case structure with integer switch

117  →Y[G⍳X]                                      X←A0; Y←I1; G←A1
     Case structure according to key vector G

118  →0×⍳X                                                    X←B0
     Conditional branch out of program

119  →Y[2+×X]                                           . X←I0; Y←I1
     Conditional branch depending on sign of X
```

```
120  →Y××X                                                  X←D0; Y←I0
     Continuing from line Y (if X>0) or exit

---
     ROLL / DEAL  ?

121  X[1]+?Yρ--/X                                           X←I1; Y←I1
     Y-shaped array of random numbers within ( X[1],X[2] ]

122  ?YρX                                                     Y←I; X←I
     Choosing Y objects out of ⍳X with replacement (roll)

123  Y?X                                                    X←I0; Y←I0
     Choosing Y objects out of ⍳X without replacement (deal)

---
     MATRIX INVERSION / MATRIX DIVISION  ⌹

124  *A+.×(⍟Y)⌹A←X∘.*0 1                                   X←D1; Y←D1
     Predicted values of exponential (curve) fit

125  A+.×Y⌹A←X∘.*0 1                                       X←D1; Y←D1
     Predicted values of best linear fit (least squares)

126  ⌽Y⌹X∘.*0,⍳G                                           X←D1; Y←D1
     G-degree polynomial (curve) fit of points (X,Y)

127  A ⍝ A[1]←*A[1] ⍝ A←(⍟Y)⌹X∘.*0 1                       X←D1; Y←D1
     Cofficients of exponential (curve) fit of points (X,Y)

128  Y⌹X∘.*0 1                                             X←D1; Y←D1
     Best linear fit of points (X,Y) (least squares)

---
     GEOMETRICAL  ○

129  ((X≠0)×¯3○Y÷X+X=0)+○((X=0)×.5××Y)+(X<0)×1-2×Y<0      X←D; Y←D
     Arctan Y÷X

130  1 2×.○X,Y                                             X←D0, Y←D0
     A way to combine trigonometric functions (sin X cos Y)

131  ○/¯2 1,X                                                    X←D0
     Complementary angle (arccos sin X)

132  2 2ρ1 ¯1 1 1×2 1 1 2○X                                      X←D0
     Rotation matrix for angle X (in radians) counter-clockwise

133  X×180÷○1                                                     X←D
     Transformation from radians to degrees

134  X×○÷180                                                      X←D
     Transformation from degrees to radians
```

```
---
     FACTORIAL / BINOMIAL  !

135  (!Y)×Y!X                                                 X←D; Y←D
     Number of permutations of X objects taken Y at a time

136  ⍉A∘.!A←0,⍳X                                                  X←I0
     Pascal's triangle of order X (binomial coefficients)

137  +/Y×(X*A)÷!A←¯1+⍳⍴Y                                     X←D0; Y←D1
     Value of Taylor series with coefficients Y at point X

138  (A!X)×(Y*A)×(1-Y)*X-A←-⎕IO-⍳X+1                         X←I0; Y←D0
     Binomial distribution of X trials with probability Y

139  ÷Y×(X-1)!Y+X-1                                          X←D0; Y←D0
     Beta function

140  (*-Y)×(Y*X)÷!X                                           X←I; Y←D0
     Poisson distribution of states X with average number Y

141  !X-1                                                         X←D0
     Gamma function

142  Y!X                                                      X←D; Y←D
     Number of combinations of X objects taken Y at a time

---
     OUTER PRODUCT  ∘.ω

143  ⍉X∘.=(1 1⍉<\X∘.=X)/X                                         X←D1
     'Position' matrix of a vector

144  ' ⎕'[⎕IO+(⌽⍳⌈/A)∘.≤A←+/(⍳1+(⌈/X)-⌊/X)∘.=X]                   X←I1
     Histogram (distribution barchart; down the page)

145  +/((¯1↓Y)∘.≤X)∧(1↓Y)∘.>X                                 X←D; Y←D1
     Distribution of X into intervals between Y

146  Y∘.×(1+G÷100)∘.*X                                   X←D; Y←D; G←D
     Compound interest for principals Y at rates G % in times X

147  (Y[A∘.+¯1+⍳⍴X]∧.=X)/A←(A=1↑X)/⍳⍴A←(1-⍴X)↓Y           X←A1; Y←A1
     Occurrences of string X in string Y

148  (1 ¯1∘.=⍉X)+.×⍳1↑⍴X                      X←I2 (1=START; ¯1=END)
     Transforming connection matrix X into a node matrix

149  0+.≠(⌈(10*Y)×10*⎕IO-⍳Y+1)∘.|⌈X×10*Y                     X←D; Y←I0
     Number of decimals (up to Y) of elements of X

150  X+.×Y∘.=((⍳⍴Y)=Y⍳Y)/Y                                   X←D1 Y←D1
     Sum over elements of X determined by elements of Y
```

```
151  (F A)+.×(A←((⍳⍴X)=X⍳X)/X)∘.=X                              X←A1
     Executing costly monadic function F on repetitive arguments

152  (G∘.=X)+.×Y                                      X←A; Y←D; G←A
     Sums according to codes G

153  1++/∧\1 2 1 3⍉Y∘.≠X                                  X←A2; Y←A2
     'X⍳Y' by rows for elements of matrices

154  (1 1⍉<\X∘.=X)/X                                             X←A1
     Removing duplicate elements (nub)

155  ⌈/(∧/0=A∘.∣X)/A←⍳⌊/X                                        X←I1
     Greatest common divisor of elements of X

156  +/(A×X÷⌈/A←Y-⌊/Y)∘.≥¯1+⍳X                            X←I0; Y←D1
     Classification of elements Y into X classes of equal size

157  -/(⍳⌈/,X)∘.=⍉X                    X←I2 (X[1;]=START; X[2;]=END)
     Transforming node matrix X into a connection matrix

158  ∧/1=+/X∘.=⍳⍴X                                               X←I1
     Test if X is a permutation vector

159  ∨/∧/0 1∘.=X                                                 X←B1
     Test if all elements of vector X are equal

160  (⍴X)⍴(,(+/A)∘.>-⎕IO-⍳¯1↑⍴X)\(,A←X≠' ')/,X                    X←C
     Moving all blanks to end of each row

161  ∧/,(0≠X)≤A∘.≤A←⍳1↑⍴X                                        X←D2
     Test if X is an upper triangular matrix

162  ∧/,(0≠X)≤A∘.≥A←⍳1↑⍴X                                        X←D2
     Test if X is a lower triangular matrix

163  +⌿(⎕IO-⍳⍴X)⌽X∘.×Y,0×1↓X                              X←D1; Y←D1
     Product of two polynomials with coefficients X and Y

164  0=(⍳⌈/X)∘.∣X                                                X←I1
     Divisibility table

165  X∘.<⌽⍳⌈/X                                                   X←I1
     Matrix with X[i] trailing zeroes on row i

166  ' ⎕'[⎕IO+(⌽⍳⌈/X)∘.≤X]                                       X←I1
     Barchart of integer values (down the page)

167  X∘.≥⌽⍳⌈/X                                                   X←I1
     Matrix with X[i] trailing ones on row i

168  X∘.<⍳⌈/X                                                    X←I1
     Matrix with X[i] leading zeroes on row i
```

169 `X∘.≥⍳⌈/X,0` X←I1
Comparison table

170 `' ⎕'[⎕IO+X∘.≥(⌈/X)×(⍳Y)÷Y]` X←D1; Y←D0
Barchart of X with height Y (across the page)

171 `' ⎕'[⎕IO+X∘.≥⍳⌈/X]` X←I1
Barchart of integer values (across the page)

172 `X∘.≥⍳⌈/X` X←I1
Matrix with X[i] leading ones on row i

173 `+/(⍳Y)∘.=⌈(X-G)÷H` X←D; Y←I0; G←D0; H←D0
Division to Y classes with width H, minimum G

174 `1 2 1⍉X∘.-⌊/X` X←D2
Move set of points X into first quadrant

175 `(2=+⌿0=(⍳X)∘.|⍳X)/⍳X` X←I0
All primes up to X

176 `(∧⌿(¯1+⍳⍴X)⌽(X∘.=Y),0)/⍳1+⍴Y` X←C1; Y←C1
Occurrences of string X in string Y

177 `⎕IO++/Y∘.≥(' '=X)/⍳⍴X` X←C1; Y←I
Ordinal numbers of words in X that indices Y point to

178 `(∧⌿(¯1+⍳⍴X)⌽X∘.=Y)⍳1` X←A1; Y←A1
First occurrence of string X in string Y

179 `Y[+⌿Y∘.≤X]` X←D0; Y←D1
Contour levels Y at points with altitudes X

180 `≠/X∘.≥Y` X←D; Y←D1
Test if X is within range [Y[1],Y[2])

181 `+/X∘.≥0 50 100 1000` X←D
Which class do elements of X belong to

182 `(((¯1⌽~A)∧A←(¯1↓X=1⌽X),0)/Y)∘.=Y` X←A1; Y←A1
Repeat matrix

183 `(⍳X)∘.⌈⍳X` X←I0
Maximum table

184 `(,Y∘.>⌽(⍳G)-⎕IO)\X` X←A1; Y←I1; G←I0
Justifying right fields of X (lengths Y) to length G

185 `(,Y∘.>(⍳G)-⎕IO)\X` X←A1; Y←I1; G←I0
Justifying left fields of X (lengths Y) to length G

186 `((⍴A)⍴Y÷100)÷A←⍉1-(1+Y÷100)∘.*-X` X←I; Y←D
Annuity coefficient: X periods at interest rate Y %

```
187  1 3 2 4⍉X∘.×Y                                   X←D2; Y←D2
     Direct matrix product

188  1 2 1 2⍉X∘.×Y                                   X←D2; Y←D2
     Shur product

189  1 2 2⍉Y∘.+X                                     X←D1; Y←D2
     Adding X to each row of Y

190  2 1 2⍉X∘.+Y                                     X←D1; Y←D2
     Adding X to each row of Y

191  1 2 1 2⍉X∘.+Y                                   X←D2; Y←D2
     Matrix sum

192  1 2 1⍉Y∘.+X                                     X←D1; Y←D2
     Adding X to each column of Y

193  1 1 2⍉X∘.+Y                                     X←D1; Y←D2
     Adding X to each column of Y

194  G⍉X∘.αY                                   X←A; Y←A; G←I1
     Selecting specific elements from a 'large' outer product

195  (⍳X)∘.≤⍳X                                              X←I0
     X×X upper triangular matrix

196  (⍳X)∘.≥⍳X                                              X←I0
     X×X lower triangular matrix

197  (⍳X)∘.=⍳X                                              X←I0
     X×X identity matrix

198  ÷¯1+(⍳X)∘.+⍳X                                          X←⍳0
     Hilbert matrix of order X

199  (⍳X)∘.×⍳X                                              X←I0
     Multiplication table

200  X[;,(Y⍴1)∘.×⍳(⍴X)[2];]                          Y←I0; X←A3
     Replicating a dimension of rank three array X Y-fold

201  (0,⍳(⍴X)-Y)∘.+Y                                   X←A1 Y←I0
     Moving index of width Y for vector X

202  X∘.+⍳Y                                          X←I1; Y←I0
     Indices of subvectors of length Y starting at X+1

203  X∘.+,0                                                 X←D1
     Reshaping numeric vector X into a one-column matrix

204  X∘.×1 ¯1                                                X←D
     Array and its negative ('plus minus')
```

INNER PRODUCT α.ω

```
205  (-2↑+/∧\⌽X∧.=' ')↓X                                      X←C2
     Removing trailing blank rows

206  ((A⍳A)=⍳⍴A←⎕IO++⌿∧⍀X∨.≠⍉X)⌿X                            X←A2
     Removing duplicate rows

207  ⎕IO++⌿∧⍀X∨.≠⍉Y                                    X←A2; Y←A2
     'X⍳Y' for rows of matrices

208  (1 1⍉<\X∧.=⍉X)⌿X                                         X←A2
     Removing duplicate rows

209  (⌽∨\⌽' '∨.≠X)/X                                          X←C2
     Removing trailing blank columns

210  (∨\' '∨.≠X)/X                                            X←C2
     Removing leading blank columns

211  (∨\X∨.≠' ')⌿X                                            X←C2
     Removing leading blank rows

212  (X⌈1↓A)⌊1↑A←(2 2⍴¯1 1 1 ¯.1)+.×10*(-1↓Y),-/Y+Y>99 0 X←D; Y←I1
     Limits X to fit in ⍕ field Y[1 2]

213  A+(X-A←⌊/X)⌈.×Y                                     X←A1; Y←B
     Maxima of elements of subsets of X specified by Y

214  X∧.=∨/X                                                  X←B1
     Test if all elements of vector X are equal

215  X∧.=∧/X                                                  X←B1
     Test if all elements of vector X are equal

216  ((((1↑⍴X),⍴Y)↑X)∧.=Y)⌿X                           X←A2; Y←A1
     Rows of matrix X starting with string Y

217  (' '≠X)⌈.×⍳¯1↑⍴X                                          X←C
     Indices of last non-blanks in rows

218  (A∨1↓1⌽1,A←X∨.≠' ')⌿X                                    X←C2
     Removing duplicate blank rows

219  ((-A)↓X∧.=(A,1+⍴Y)⍴Y)/⍳(⍴Y)+1-A←⍴X               X←A1; Y←A1
     Occurrences of string X in string Y

220  (A∨1,¯1↓A←' '∨.≠X)/X                                     X←C2
     Removing duplicate blank columns

221  ~X≤.≥(⌈X),G,H                               X←I0; G←I0; H←I0
     Test if X is an integer within range [ G,H )
```

```
222  Y⌈.×X                                        X←D1; Y←D1
     Maximum of X with weights Y

223  Y⌊.×X                                        X←D1; Y←D1
     Minimum of X with weights Y

224  X←X⌊.+X                                            X←B2
     Extending a distance table to next leg

225  (X∨.≠' ')⌿X                                        X←C2
     Removing blank rows

226  (' '∨.≠X)/X                                        X←C2
     Removing blank columns

227  (X*¯1+⍳⍴Y)+.×⌽Y                               X←D0; Y←D
     Value of polynomial with coefficients Y at point X

228  1∊X∧.=Y                                       X←A; Y←A1
     Test if vector Y is a row of array X

229  (Y∧.=X)⍳1                         X←A2; Y←A1; ¯1↑⍴Y↔⍴X
     First occurrence of string X in matrix Y

230  X←X∨.∧X                                            X←B2
     Extending a transitive binary relation

231  X∨.≠Y                                         X←A; Y←A0
     Test if rows of X contain elements differing from Y

232  X∧.=Y                                         X←A; Y←A1
     Comparing vector Y with rows of array X

233  X<.<Y                            X←D0; Y←D2; 1↑⍴Y ↔ 2
     Test if X is within range [ Y[1;],Y[2;] )

234  X<.≤Y                             X←D; Y←D2; 1↑⍴Y ↔ 2
     Test if X is within range ( Y[1;],Y[2;] ]

235  (X,[.1+⍴⍴X]X)>.>Y                 X←D; Y←D2; 1↑⍴Y ↔ 2
     Test if X is within range ( Y[1;],Y[2;] ]

236  X+.=,Y                                        X←A0; Y←A
     Number of occurrences of scalar X in array Y

237  (Y+.×X)÷⍴X                                   X←D1; Y←D1
     Arithmetic average (mean value) of X weighted by Y

238  Y-.÷X                                        X←D1; Y←D1
     Sum of alternating reciprocal series Y÷X

239  Y+.÷X                                        X←D1; Y←D1
     Sum of reciprocal series Y÷X
```

```
240  X+.×Y                                  X←D; Y←D; ¯1↑ρX ↔ 1↑ρY
     Matrix product

241  X+.×Y                                                X←A1; Y←B
     Summation over subsets of X specified by Y

242  X+.×X                                                     X←D1
     Sum of squares of X

243  Y+.×X                                               X←D1; Y←D1
     Scalar (dot) product of vectors

244  X×.*Y                                                X←A1; Y←B
     Products over subsets of X specified by Y

245  ⎕RL←⎕TS+.*2
     Randomizing random numbers (in ⎕LX in a workspace)

246  X+.*2                                                     X←D1
     Sum of squares of X

---
     SCAN  ω\ ω⍀

247  (⍳+/X,Y)∊+\1+¯1↓0,((⍳+/X)∊+\X)\Y                        Q←I1; Y←I1
     Vector (X[1]ρ1),(Y[1]ρ0),(X[2]ρ1),...

248  (A-⌊0.5×(A←+/∧\⌽A)++/∧\A←' '=⌽X)⌽X                            X←C
     Centering character array X with ragged edges

249  ⎕IO++\1+((⍳+/X)∊+\⎕IO,X)\Y-¯1↓1,X+Y         X←I1; Y←I1; ρX↔ρY
     Vector (Y[1]+⍳X[1]),(Y[2]+⍳X[2]),(Y[3]+⍳X[3]),...

250  Y[+\(⍳+/X)∊¯1↓1++\0,X]                      X←I1; Y←A1; ∧/0<X
     Replicate Y[i] X[i] times (for all i)

251  ((X≠0)/Y)[+\¯1⌽(⍳+/X)∊+\X]                             X←I1; Y←A1
     Replicate Y[i] X[i] times (for all i)

252  ≠\(⍳+/X)∊+\⎕IO,X                                     X←I1; ∧/0<X
     Vector (X[1]ρ1),(X[2]ρ0),(X[3]ρ1),...

253  Y[⎕IO++\(⍳+/X)∊⎕IO++\X]                     X←I1; Y←A1; ∧/0<X
     Replicate Y[i] X[i] times (for all i)

254  ≠\Y≠X\A≠¯1↓0,A←X/≠\¯1↓0,Y                               X←B1; Y←B1
     Running parity (≠\) over subvectors of Y indicated by X

255  +\Y-X\A-¯1↓0,A←X/+\¯1↓0,Y                               X←B1; Y←D1
     Cumulative sum (+\) over subvectors of Y indicated by X

256  Y∧A=⌈\X×A←+\Y>¯1↓0,Y                                     X←B; Y←B
     Groups of ones in Y pointed by X (or trailing parts)
```

```
257  A-¯1↓0,A←(+\X)[+\Y]                             X←D1; Y←I1
     Sums over (+/) subvectors of X, lengths in Y

258  (⍴X)⍴A\(A←,∧\('⍝'≠X)∨≠\X='''')/,X                      X←C2
     Decommenting a matrix representation of a function (⎕CR)

259  ((⌽∨\⌽A)∧∨\A←' '≠X)/X                                  X←C1
     Removing leading and trailing blanks

260  +\+\⍳X                                                  X←I0
     X first figurate numbers

261  X∧∧\X=∨\X                                                X←B
     First group of ones

262  (<\,(X=(⍴X)⍴⌈⌿X)∧X=⍉(⌽⍴X)⍴⌊/X)/,X                      X←D2
     Value of saddle point

263  ((~(⍴A↑X)↑'/'=Y)/A↑X),(1↓A↓Y),(A←+/∧\Y≠',')↓X    X←C1; Y←C1
     Editing X with Y ∇-wise

264  ((⍳(⍴Y)++/X)∊+\1+0,¯1↓((⍳⍴Y)∊G)\X)\Y       X←I1; Y←A1; G←I1
     Open a gap of X[i] after Y[G[i]] (for all i)

265  (⍳(⍴Y)++/X)∊+\1+¯1↓0,(1⌽Y)\X                     X←I1; Y←B1
     Insert vector for X[i] zeroes after i:th subvector

266  (-+/∧\' '=⌽X)↓X                                        X←C1
     Removing trailing blanks

267  (+/∧\' '=X)↓X                                          X←C1
     Removing leading blanks

268  ∧/[Y]X=⌈\[Y]X                                       X←D; Y←I0
     Test if X is in ascending order along direction Y

269  (-⌊0.5×+/∧\' '=⌽X)⌽X                                    X←C
     Centering character array X with only right edge ragged

270  ∧/[Y]X=⌊\[Y]X                                       X←D; Y←I0
     Test if X is in descending order along direction Y

271  ((⍳(⍴Y)++/X)∊+\1+((⍳⍴Y)∊G)\X)\Y             X←I1; Y←A1; G←I1
     Open a gap of X[i] before Y[G[i]] (for all i)

272  (⌽∨\⌽∨⌿' '≠X)/X                                        X←C2
     Removing trailing blank columns

273  X,[⎕IO-(⍲\2⍴∧/2>(⍴⍴X),⍴⍴Y)/.5 0]Y                   X←A; Y←A
     Vectors as matrices in catenation

274  X,[⎕IO+(⍲\2⍴∧/2>(⍴⍴X),⍴⍴Y)/.5 1]Y                   X←A; Y←A
     Vectors as matrices in catenation
```

```
275  (-+/∧\' '=⌽X)⌽X                                                X←C
     Justifying right

276  (+/∧\' '=X)⌽X                                                  X←C
     Justifying left

277  (⍳+/X)∊(+\X)-~⎕IO                                             X←I1
     Changing lengths of subvectors to ending indicators

278  (⍳+/X)∊+\⎕IO,X                                                X←I1
     Changing lengths of subvectors to starting indicators

279  (⍳+/A)∊+\A←1+X                                                X←I1
     Insert vector for X[i] elements before i:th element

280  (+\X)⍳⍳+/X                                                    X←B1
     Indices of ones in logical vector X

281  +/Y××\1,X÷⍳¯1+⍴Y                                        X←D0; Y←D1
     Value of Taylor series with coefficients Y at point X

282  ⎕IO++/∧\' '≠X                                                  X←C
     Indices of first blanks in rows of array X

283  (Y=+\X=1↑X)/X                                           Y←I0; X←C1
     Locating field number Y starting with first element of X

284  A-¯1↓0,A←(Y≠1↓Y,0)/+\X                                  X←D1; Y←D1
     Sum elements of X marked by succeeding identicals in Y

285  ((Y-1)↓A)-0,(-Y)↓A←+\X                                  X←D1; Y←I0
     Running sum of Y consecutive elements of X

286  G-¯1↓0,G←0⌈(+\Y)-X                                      Y←D1; X←D0
     Fifo stock Y decremented with X units

287  A∨¯1↓0,A←2|+\X=''''                                           X←C1
     Locations of texts between and including quotes

288  A∧¯1↓0,A←2|+\X=''''                                           X←C1
     Locations of texts between quotes

289  ≠\(Y∨X)\A≠¯1↓0,A←(Y∨X)/Y                                X←B1; Y←B1
     Or-scan (∨\) over subvectors of Y indicated by X

290  ~≠\(Y≤X)\A≠¯1↓0,A←~(Y≤X)/Y                              X←B1; Y←B1
     And-scan (∧\) over subvectors of Y indicated by X

291  A-¯1↓0,A←(1⌽X)/+\Y                                      X←B1; Y←D1
     Sums over (+/) subvectors of Y indicated by X

292  Y∧A∊(X∧Y)/A←+\Y>¯1↓0,Y                                  X←B1; Y←B1
     Groups of ones in Y pointed by X
```

```
293  A∨¯1↓0,A←≠\X=''''                                     X←C1
     Locations of texts between and including quotes

294  A∧¯1↓0,A←≠\X=''''                                     X←C1
     Locations of texts between quotes

295  +\('('=X)-¯1↓0,')'=X                                  X←C1
     Depth of parentheses

296  +\¯1↓⎕IO,X                                            X←I1
     Starting positions of subvectors (lengths in X)

297  X[1⌈⌈\Y×⍳⍴Y]                                    X←A1; Y←B1
     Duplicating element of X belonging to Y,1↑X until next found

298  (⌽∨\⌽' '≠X)/X                                         X←C1
     Removing trailing blanks

299  (∨\' '≠X)/X                                           X←C1
     Removing leading blanks

300  (G=+\X)/Y                                  X←A1; Y←B1; G←I0
     G:th subvector of Y (subvectors indicated by X)

301  -\⍳X                                                  X←I0
     Alternating series (1 ¯1 2 ¯2 3 ¯3 ...)

302  +\⍳X                                                  X←I0
     X first triangular numbers

303  X∨≠\X                                                  X←B
     Joining pairs of ones

304  ∨\X                                                    X←B
     Turn on all zeroes after first one

305  (~X)∧≠\X                                               X←B
     Places between pairs of ones

306  ∧\X                                                    X←B
     Turn off all ones after first zero

307  <\X                                                    X←B
     Turn off all ones after first one

308  ≤\X                                                    X←B
     Turn on all zeroes after first zero

309  ≠\X                                                    X←B
     Running parity

310  +\X                                                    X←D
     Cumulative sum
```

REDUCTION ω/ ω⌿

```
311  (⌈/X)=⌊/X                                             X←D1
     Test if all elements of vector X are equal

312  (⌈/X)-⌊/X                                             X←D1
     Size of range of elements of X

313  -/×⌿0 1⌽X                                             X←D2
     Evaluating a two-row determinant

314  -/×/0 1⊖X                                             X←D2
     Evaluating a two-row determinant

315  (∧/X)∨~∨/X                                            X←B1
     Test if all elements of vector X are equal

316  (∧/X)=∨/X                                             X←B1
     Test if all elements of vector X are equal

317  ∧/X÷∨/X                                               X←B1
     Test if all elements of vector X are equal

318  (×/(+/X÷2)-0,X)*.5                           X←D1; 3 ↔ ρX
     Area of triangle with side lengths in X (Heron's formula)

319  ((+/(X-(+/X)÷ρX)*2)÷ρX)*.5                            X←D1
     Standard deviation of X

320  (+/(X-(+/X)÷ρX)*2)÷ρX                                 X←D1
     Variance (dispersion) of X

321  (+/(X-(+/X)÷ρX)*Y)÷ρX                                 X←D1
     Y:th moment of X

322  ∧/((1↑X)∊10↓A),X∊A←'0..9A..ZΔA̲..X̲Δ̲'                     X←C1
     Test if X is a valid APL name

323  Y↑((⌊-/.5×Y,ρX)ρ' '),X                          X←C1; Y←I0
     Centering text line X into a field of width Y

324  ∧/X=1↑X                                               X←A1
     Test if all elements of vector X are equal

325  (+/X)÷¯1↑1,ρX                                         X←D2
     Average (mean value) of rows of matrix X

326  (+⌿X)÷1↑(ρX),1                                        X←D2
     Average (mean value) of columns of matrix X

327  (¯1⌽1↓(∨/X≠¯1⊖X),1)⌿X                                 X←A2
     Removing duplicate rows from ordered matrix X
```

328 `×/¯1↓⍴X` X←A
Number of rows in array X (also of a vector)

329 `(⍳⌈/X)∊X` X←I1
Converting set of positive integers X into a mask

330 `X⍳⌈/X` X←D1
Index of (first) maximum element of X

331 `⌈/⍳0`
Negative infinity; the smallest representable value

332 `(+/,X)÷1⌈⍴,X` X←D
Arithmetic average (mean value), also for an empty array

333 `A[X] ∆ A[Y]←1 ∆ A←(⌈/X,Y)⍴0` X←I1; Y←I1
Quick membership (∊) for positive integers

334 `⌈/X,0` X←D1
Positive maximum, at least zero (also for empty X)

335 `⌈/X` X←D1
Maximum of elements of X

336 `X⍳⌊/X` X←D1
Index of (first) minimum element of X

337 `⌊/⍳0`
Positive infinity; the largest representable value

338 `⌊/X⍳Y` X←C1; Y←C1
Index of first occurrence of elements of Y

339 `⌊/X` X←D1
Minimum of elements of X

340 `0=(⍴X)|+/X` X←B1
Test if all elements of vector X are equal

341 `∧/X/1⌽X` X←B1
Test if all elements of vector X are equal

342 `+/A×¯1*A<1⌽A←0,1000 500 100 50 10 5 1['MDCLXVI'⍳X]` X←A
Interpretation of roman numbers

343 `∧/X=1⌽X` X←A1
Test if all elements of vector X are equal

344 `∧/X=1⊖X` X←A2
Comparison of successive rows

345 `∧/(X∊Y),Y∊X` X←A1; Y←A1
Identity of two sets

346 `∧/(⍳⍴X)∊X` X←I1
Test if X is a permutation vector

347 `⍲/0 1∊X` X←B1
Test if all elements of vector X are equal

348 `∨/Y∊X` X←A; Y←A1
Test if X and Y have elements in common

349 `~∧/X∊~X` X←B1
Test if all elements of vector X are equal

350 `∧/,X∊0 1` X←A
Test if X is boolean

351 `∧/Y∊X` X←A; Y←A1
Test if Y is a subset of X (Y ⊂ X)

352 `≠/0 1∊X` X←B1
Test if all elements of vector X are equal

353 `∧/(X⍳X)=⍳⍴X` X←A1
Test if each element of X occurs only once

354 `∧/⎕IO=X⍳X` X←A1
Test if all elements of vector X are equal

355 `~∨/X` X←B
None, neither

356 `∨/X` X←B
Any, anyone

357 `∧/,X=Y` X←A; Y←A; ⍴X ↔ ⍴Y
Test if arrays of equal shape are identical

358 `∧/X=X[1]` X←A1
Test if all elements of vector X are equal

359 `∧/' '=X` X←C2
Blank rows

360 `∧/X` X←B
All, both

361 `≠/X` X←B
Parity

362 `+/X=,Y` X←A0; Y←A
Number of occurrences of scalar X in array Y

363 `(-X[2]-¯1 1×((X[2]*2)-×/4,X[1 3])*.5)÷2×X[1]` X←D1; 3 ↔ ⍴X
(Real) solution of quadratic equation with coefficients X

```
364  (+/[Y]X)÷(ρX)[Y]                                X←D; Y←I0
     Average (mean value) of elements of X along direction Y

365  (+/X)÷ρX                                              X←D1
     Arithmetic average (mean value)

366  ×/ρX                                                   X←A
     Number of elements (also of a scalar)

367  ÷/X                                                    X←D
     Alternating product

368  ×/X                                                   X←D1
     Product of elements of X

369  -/X                                                    X←D
     Alternating sum

370  +/X                                                   X←B1
     Number of elements satisfying condition X

371  +/X                                                   X←A1
     Reshaping one-element vector X into a scalar

372  +⌿X                                                   X←D2
     Column sum of a matrix

373  +/X                                                   X←D2
     Row sum of a matrix

374  +/X                                                   X←D1
     Sum of elements of X

---
     TAKE  ↑

375  Y[⍳G;],[1]((1↓ρY)↑X),[1](2↑G)↓Y         X←A1; Y←A2; G←I0
     Inserting vector X into matrix Y after row G

376  (A↑X),[⍳1](1↓A←(ρX)⌈0,ρY)↑Y                    X←A2; Y←A1
     Inserting vector Y to the end of matrix X

377  Y↑X,Yρ¯1↑X                                     X←A1; Y←I0
     Filling X with last element of X to length Y

378  X[Y;]←(1↑ρX)↑⍞                                 X←C2; Y←I0
     Input of row Y of text matrix X

379  (1↑A)↓(A⍲1⌽A←X=Y)/X                            X←A1; Y←A0
     Removing leading, multiple and trailing Y's

380  X←(ρX)ρA ∆ A[(A=1↑Y)/⍳ρA←,X]←1↓Y                X←A; Y←A1
     Changing elements in X with value Y[1] into Y[2]
```

381 `X>((-ρρX)↑¯1)↓0,X` `X←B`
First ones in groups of ones

382 `(G↑Y),X,G↓Y` `X←A1; Y←A1; G←I0`
Inserting X into Y after index G

383 `X-((-ρρX)↑¯1)↓0,X` `X←D`
Pairwise differences of successive columns (inverse of +\)

384 `((-ρρX)↑1)↓X,0` `X←D`
Rightmost neighboring elements

385 `((-ρρX)↑¯1)↓0,X` `X←D`
Leftmost neighboring elements

386 `(-ρX)↑(-Y)↓X` `X←A1; Y←I0`
Shifting vector X right with Y without rotate

387 `(ρX)↑Y↓X` `X←A1; Y←I0`
Shifting vector X left with Y without rotate

388 `(2↑Y)↓X` `X←A2; Y←I0`
Drop of Y first rows from matrix X

389 `,⍉(Aρ2)ρ(2*A←⌈2⍟X)↑⍳X` `X←I0`
Playing order in a cup for X ranked players

390 `((1 0×ρY)⌈ρX)↑X` `X←A2; Y←A2`
Lengthening matrix X to be compatible with Y

391 `((0 1×ρY)⌈ρX)↑X` `X←A2; Y←A2`
Widening matrix X to be compatible with Y

392 `(1⌈¯2↑ρX)ρX` `X←A; 2≥ρρX`
Reshaping non-empty lower-rank array X into a matrix

393 `(-⌊.5×Y+ρX)↑X` `X←C1; Y←I0`
Centering text line X into a field of width Y

394 `(X⌊ρY)↑Y` `X←I; Y←A`
Take of at most X elements from Y

395 `(¯1↑ρY)|(,Y)⍳X` `Y←C2; X←C`
Alphabetizing X; equal alphabets in same column of Y

396 `(~(⍳¯1↑ρX)∊Y)/X` `X←A; Y←I1`
Removing columns Y from array X

397 `(¯1↑(' '≠X)/⍳ρX)ρX` `X←C1`
Removing trailing blanks

398 `(1-⍳¯1↑ρX)⌽X` `X←A2`
Aligning columns of matrix X to diagonals

399 `(¯1+⍳¯1↑⍴X)⌽X` *X←A2*
Aligning diagonals of matrix X to columns

400 `0∊1↑0⍴X` *X←A*
Test if numeric

401 `(¯1+X⍳' ')↑X` *X←C1*
First word in X

402 `(¯2↑1 1,⍴X)⍴X` *X←A; 2≥⍴⍴X*
Reshaping non-empty lower-rank array X into a matrix

403 `1↑⍞,X` *X←C0*
Giving a character default value for input

404 `(X×Y)⍴(-Y)↑1` *X←I0; Y←I0*
Ending points for X fields of width Y

405 `(X×Y)⍴Y↑1` *X←I0; Y←I0*
Starting points for X fields of width Y

406 `X+(-⍴X)↑Y` *X←D; Y←D0*
Adding scalar Y to last element of X

407 `Y↑X⍴1` *X←I0; Y←I0*
Vector of length Y with X ones on the left, the rest zeroes

408 `1 80⍴80↑X` *X←A1*
Forming first row of a matrix to be expanded

409 `1↑0⍴X` *X←A*
Zero or space depending on the type of X (fill element)

410 `¯1↑⍴X` *X←A2*
Number of columns in matrix X

411 `1↑⍴X` *X←A2*
Number of rows in matrix X

412 `(-Y)↑X` *Y←I0; X←C1*
Transferring text X to right edge of field of width Y

DROP ↓

413 `(1↓A)-¯1↓A←(A,1)/⍳1+⍴A←1,(1↓X)≠¯1↓X` *X←A1*
Lengths of subvectors with equal elements

414 `G-¯1↓0,G←(~⎕IO)+(((1↓X)≠¯1↓X),1)/⍳⍴X` *X←A1; G←I1*
Field lengths of vector X; G ↔ ending indices

415 `(A>0)/A←(1↓A)-1+¯1↓A←(~A)/⍳⍴A←0,X,0` *X←B1*
Lengths of groups of ones in X

```
416  ((A⍳1)-⎕IO)↓(⎕IO-(⌽A←~X∊Y)⍳1)↓X                   X←A1; Y←A
     Removing elements Y from beginning and end of vector X

417  ((1↓X)≠¯1↓X),1                                              X←A1
     Ending points of equal groups

418  1,(1↓X)≠¯1↓X                                                X←A1
     Starting points of equal groups

419  (1↓X)÷¯1↓X                                                  X←D1
     Pairwise ratios of successive elements of vector X

420  (1↓X)-¯1↓X                                                  X←D1
     Pairwise differences of successive elements of vector X

421  (Y∧X)∨(Y∨X)\A>¯1↓0,A←(Y∨X)/Y                         X←B1; Y←B1
     First ones of subvectors of Y indicated by X (<\)

422  (¯1⌽1↓(X≠¯1⌽X),1)/X                                         X←A1
     Removing duplicates from an ordered vector

423  A-¯1↓0,A←(1⌽X)/⍳⍴X                                          X←B1
     Changing starting indicators of subvectors to lengths

424  (A∨1↓1⌽1,A←' '≠X)/X                                         X←C1
     Removing multiple blanks

425  (⍴X)⍴A ∆ A[(A=1⍴Y)/⍳⍴A←,X]←1↓Y              X←A; Y←A1; 2 ↔ ⍴Y
     Replacing all values Y[1] by Y[2] in X

426  (A∨¯1↓1,A←X≠Y)/X                                      X←A1; Y←A0
     Removing duplicate Y's from vector X

427  (⎕IO-(~⌽X∊Y)⍳1)↓X                                      X←A1; Y←A
     Removing elements Y from end of vector X

428  (1-(⌽' '≠X)⍳1)↓X                                           X←C1
     Removing trailing blanks

429  0 ¯1↓(-⍳⍴X)⌽((2⍴⍴X)⍴0),X                                    X←D1
     Diagonal matrix with elements of X

430  ¯1↓X×⌽¯1+⍳⍴X                                                X←D1
     Derivate of polynomial X

431  (¯1↓X≠1⌽X),1                                                X←A1
     Test if an element differs from the next one

432  1,1↓X≠¯1⌽X                                                  X←A1
     Test if an element differs from the previous one

433  1⌽¯1↓Y,X                                              X←A1; Y←A0
     Replacing last element of X with Y
```

```
434  ¯1⌽1↓X,Y                                      X←A1; Y←A0
     Replacing first element of X with Y

435  (((~X∊Y)⍳1)-⎕IO)↓X                             X←A1; Y←A
     Removing elements Y from beginning of vector X

436  X-(-Y=⍳⍴⍴X)↓0,[Y]X                             X←D; Y←I0
     Differences of successive elements of X along direction Y

437  (¯1+(X='0')⍳0)↓X                                     X←A1
     Removing leading zeroes

438  Y+(Y↓X)⍳1                                     G←I0; X←B1
     Index of first one after index Y in X

439  X>1↓X,0                                              X←B1
     Last ones in groups of ones

440  X>¯1↓0,X                                             X←B1
     First ones in groups of ones

441  1↓,',',X                                             X←C2
     List of names in X (one per row)

442  X-¯1↓0,X                                             X←D1
     Restoring argument of cumulative sum (inverse of +\)

443  (0,Y)↓X                                         X←A2;Y←I0
     Drop of Y first columns from matrix X

444  (Y,0)↓X                                        X←A2; Y←I0
     Drop of Y first rows from matrix X

445  1↓⍴X                                                 X←A2
     Number of columns in matrix X

446  ¯1↓⍴X                                                X←A2
     Number of rows in matrix X

447  (Y×G)↓X                                  X←A; Y←I1; G←B1
     Conditional drop of Y elements from array X

448  (-Y)↓X                                         X←A1; Y←B0
     Conditional drop of last element of X

---
     CEILING / MAXIMUM  ⌈

449  Y[1]⌈Y[2]⌊X                                     X←D; Y←D1
     Limiting X between Y[1] and Y[2], inclusive

---
     FLOOR / MINIMUM  ⌊
```

```
450  ⌊|10⍟|1-3×÷3
     Arithmetic precision of the system (in decimals)

451  X+(G××Y-X)×(⍳1+|⌊(Y-X)÷G)-⎕IO             X←D0; Y←D0; G←D0
     Arithmetic progression from X to Y with step G

452  1+(X<0)+⌊10⍟|X+0=X                                      X←I
     Number of digitpositions in integers in X

453  ⌊X+1≤2|X                                                X←D
     Rounding to nearest even integer

454  ⌊X+.5×.5≠2|X                                            X←D
     Rounding, to nearest even integer for .5 = 1||X

455  1+⌊10⍟(X=0)+X×1 ¯10[1+X<0]                              X←I
     Number of digit positions in integers in X

456  1+⌊10⍟X+0=X                                             X←I
     Number of digits in positive integers in X

457  X=⌊X                                                    X←D
     Test if integer

458  (X,G)[(1+⍴X)⌊Y]                             X←A1; Y←I; G←A0
     Limiting indices and giving a default value G

459  ⌊X÷1000                                                 X←I
     First part of numeric code ABBB

460  (10*-X)×⌊0.5+Y×10*X                               X←I; Y←D
     Rounding to X decimals

461  0.01×⌊0.5+100×X                                         X←D
     Rounding to nearest hundredth

462  ⌊0.5+X                                                  X←D
     Rounding to nearest integer

---
     MAGNITUDE / RESIDUE  |

463  (0=400|X)∨(0≠100|X)∧0=4|X                               X←I
     Test if X is a leap year

464  '_',[1]('|',X,'|'),[1]'¯'                              X←C2
     Framing

465  1||X                                                    X←D
     Magnitude of fractional part

466  (0≠Y|⍳⍴X)/X                                       X←A1; Y←I0
     Removing every Y:th element of X
```

```
467  (0=Y|⍳⍴X)/X                                          X←A1; Y←I0
     Taking every Y:th element of X

468  (0=A|X)/A←⍳X                                              X←I0
     Divisors of X

469  (2|⍳⍴X)/X                                                 X←A1
     Removing every second element of X

470  (0=Y|X)/X                                    X←D1; Y←D0 or D1
     Elements of X divisible by Y

471  ⎕IO+(⍴X)|Y+(Y⌽X)⍳G                           X←A1; Y←I0; G←A
     Index of first occurrence of G in X (circularly) after Y

472  (1+⍴Y)|Y⍳X                                          Y←A1; X←A
     Changing index of an unfound element to zero

473  ~2|X                                                        X←I
     Test if even

474  X×Y≤|X                                               X←D; Y←D
     Rounding to zero values of X close to zero

475  (×X)×Y+|X                                            X←D; Y←D
     Increasing absolute value without change of sign

476  (×X)|X                                                      X←D
     Fractional part with sign

477  X×|X                                                        X←D
     Square of elements of X without change of sign

478  1|X                                                         X←D
     Fractional part

479  1000|X                                                      X←I
     Last part of numeric code ABBB

---
     EXPAND  \

480  A\(A←~X∊Y)/X                                         X←A0; Y←A1
     Replacing elements of X in set Y by blanks / zeroes

481  A\(A←X∊Y)/X                                           X←A1; Y←A
     Replacing elements of X not in set Y by blanks / zeroes

482  A ∆ A[(~G)/⍳⍴G]←Y  ∆  A←G\X                 X←A1; Y←A1; G←B1
     Merging X and Y under control of G (mesh)

483  Y\Y/X                                                X←A; Y←B1
     Replacing elements of X not fulfilling Y by blanks / zeroes
```

```
484  ⌽α\⌽X                                                X←A
     Scan from end with α

485  (~(⍳(⍴Y)+1⍴⍴X)∊Y+⍳⍴Y)⍀X                      X←A2; Y←I1
     Adding an empty row into X after rows Y

486  0∊0\0⍴X                                             X←A1
     Test if numeric

487  ((Y+1)≠⍳1+1⍴⍴X)⍀X                             X←A2; Y←I0
     Adding an empty row into X after row Y

488  X,[⎕IO-.1](' '≠X)\'¯'                               X←C1
     Underlining words

489  (⍴Y)⍴(,Y)\X                                   X←A1; Y←B2
     Using boolean matrix Y in expanding X

490  ((2×⍴X)⍴1 0)\X                                      X←C1
     Spacing out text
```

———

COMPRESS /

```
491  (X/Y)≥A/1⌽A←(Y∨X)/X                           X←B1; Y←B1
     Or-reduction (∨/) of subvectors of Y indicated by X

492  (X/Y)∧A/1⌽A←(Y≤X)/X                           X←B1; Y←B1
     And-reduction (∧/) of subvectors of Y indicated by X

493  (G/X),(~G)/Y                           X←C1; Y←C1; G←B0
     Choosing a string according to boolean value G

494  (A∨1⌽A←X≠' ')/X                                     X←C1
     (Cyclic) compression of successive blanks

495  (X∊Y)/⍳⍴X                                      X←A1; Y←A
     Indices of all occurrences of elements of Y in X

496  (~X∊' .,:;?''')/X                                   X←A1
     Removing punctuation characters

497  Y,(~X∊Y)/X                                    X←A1; Y←A1
     Union of sets, ∪

498  (~X∊Y)/X                                       X←A1; Y←A
     Elements of X not in Y (difference of sets)

499  (X[;1]∊Y)⌿X                                   X←A2; Y←A1
     Rows of non-empty matrix X starting with a character in Y

500  (X∊Y)/X                                        X←A1; Y←A
     Intersection of sets, ∩
```

501 ((X⍳X)=⍳⍴X)/X   X←A1
Removing duplicate elements (nub)

502 ((⍴X)*Y≠⍳⍴⍴X)⍴ α/[Y]X   Y←I0; X←A
Reduction in dimension Y, rank unchanged

503 (Y=X)/⍳⍴X   X←A1; Y←A0
Indices of all occurrences of Y in X

504 Y[X/⍳⍴Y]←G   Y←A1 X←B1 G←A0
Replacing elements of Y satisfying X with G

505 A/⍳9999 Δ A[X]←1 Δ A←9999⍴0   X←I1
Removing duplicates from positive integers

506 X/⍳⍴X   X←B1
Indices of ones in logical vector X

507 (,X,[1.5]1)/,X,[1.5]~X   X←B1
Vector to expand a new element after each one in X

508 ((~X)/'IN'),'CORRECT'   X←B0
Conditional in text

509 (X≠Y)/X   X←A1; Y←A0
Removing elements Y from vector X

510 (' '≠X)/X   X←A1
Removing blanks

511 α/,X   X←D
Reduction with α without respect to shape

512 Y/X   X←A; Y←B1
Selecting elements of X satisfying condition Y

513 0⌿X   X←A2
Empty matrix

TRANSPOSE ⍉

514 ⍉F⍉X   X←A1; Y←I0
Applying to columns function F defined on rows

515 ((⌽A)×1,Y)⍴2 1 3⍉(1⌽Y,A←(⍴X)÷1,Y)⍴X   X←A2; G←I0
"Transpose" of matrix X with column fields of width Y

516 X×⍉(⌽⍴X)⍴Y   X←D2; Y←D1
Multiplication of each column of matrix X by vector Y

517 ⍉(⌽⍴Y)⍴X   X←A1; Y←A2
Matrix with shape of Y and X as its columns

```
518  (Y⌽1 2)⍉X                                          X←A2; Y←B0
     Transpose matrix X on condition Y

519  ~0∊X=-⍉X                                                 X←D2
     Test for antisymmetricity of square matrix X

520  ~0∊X=⍉X                                                  X←A2
     Test for symmetricity of square matrix X

521  ⍉(X,⍴Y)⍴Y                                          X←I0; Y←D1
     Matrix with X columns Y

522  1 1⍉X[Y[1;];Y[2;]]                                 X←A2; Y←I2
     Retrieving scattered elements Y from matrix X

523  X[Y]⍉G                                             X←I1; Y←I1
     Successive transposes of G (X after Y: X⍉Y⍉G)

524  40 120⍴2 1 3⍉10 40 12⍴X                                  X←C2
     Dividing a 400×12 character matrix into one page

525  (1*⍴X)⍉X                                                  X←A
     Main diagonal of array X

526  1 1⍉X                                                    X←A2
     Diagonal elements of matrix X

527  1 3 2⍉X                                                  X←A3
     Transpose of planes of a rank three array

---
```

REVERSE / ROTATE ⌽ ⊖

```
528  ((1⌽X)×¯1⌽Y)-(¯1⌽X)×1⌽Y                              X←D; Y←D
     Vector (cross) product of vectors

529  1⌽(⍳⍴X)∊Y                                          X←A1; Y←I1
     Ending points for X in indices pointed by Y

530  (¯1 1[2×⎕IO]+⍴X)-(⌽X)⍳Y                            X←A1; Y←A0
     Index of last element of Y in X

531  (1+⍴X)-(⌽X)⍳Y                                       X←A1; Y←A
     Index of last occurrence

532  (⌽X)⍳Y                                              X←A1; Y←A
     Index of last occurrence, counted from the rear

533  ,⌽[⎕IO+Y](1,⍴X)⍴X                                  X←A1; Y←B0
     Reverse vector X on condition Y

534  (⌽1,⍴X)⍴X                                                X←A1
     Reshaping vector X into a one-column matrix
```

535 (⌽1, ...) ...←EXPRESSION
Avoiding parentheses with help of reversal

536 1⌽X X←A
Rightmost neighboring elements cyclically

537 ¯1⌽X X←A
Leftmost neighboring elements cyclically

MEMBER OF ∊

538 ~(⍳(⍴Y)+⍴X)∊Y+⍳⍴Y X←A1; Y←I1
Expansion vector with zero after indices Y

539 (~(⍳Y)∊X) X←I; Y←I0
Boolean vector of length Y with zeroes in locations X

540 (⍳⍴X)∊Y X←A1; Y←I1
Starting points for X in indices pointed by Y

541 (X∊Y)×Y⍳X X←A; Y←A1
Changing index of an unfound element to zero (not effective)

542 (Y←⎕)∊⍳X X←A
Check for input in range 1..X

543 (⍳Y)∊X X←I; Y←I0
Boolean vector of length Y with ones in locations X

544 ~0∊X=Y X←A; Y←A
Test if arrays are identical

545 Y×~Y∊X Y←D; X←D
Zeroing elements of Y depending on their values

546 1∊⍴,X X←A
Test if single or scalar

547 1∊⍴⍴X X←A
Test if vector

548 0∊⍴X X←A
Test if X is an empty array

INDEX GENERATOR / INDEX OF ⍳

549 (G⍳X)<G⍳Y X←A; Y←A
Alphabetical comparison with alphabets G

550 X⍳⍳⍴X X←I1
Inverting a permutation

```
551  (Y≠X)⍳1                                           X←A1; Y←A1
     Index of first differing element in vectors X and Y

552  (⎕IO+⍴Y)=Y⍳X                                       X←A; Y←A1
     Which elements of X are not in set Y (difference of sets)

553  A Δ A[X]←A Δ A←⍳⍴X                                       X←I1
     Inverting a permutation

554  G[Y⍳X;]                                     X←D; Y←D1; G←C2
     Changing numeric code X into corresponding name in Y

555  ⍳⍴⍴X                                                       X←A
     All axes of array X

556  ⍳⍴X                                                       X←A1
     All indices of vector X

557  X+G×(⍳Y)-⎕IO                               X←D0; Y←D0; G←D0
     Arithmetic progression of Y numbers from X with step G

558  (X-⎕IO)+⍳1+Y-X                                    X←I0; Y←I0
     Consecutive integers from X to Y (arithmetic progression)

559  X⍳1                                                       X←B1
     Index of first satisfied condition in X

560  ⍳1
     Index origin (⎕IO) as a vector

561  ⎕AV⍳X                                                      X←A
     Converting characters into numeric codes

562  X⍳Y                                                 X←A1; Y←A
     Index of key Y in key vector X

563  ⍳0
     Empty numeric vector

---
     LOGICAL ~ ∨ ∧ ⍱ ⍲

564  (Y[1]<X)∧X<Y[2]                                    X←D; Y←D1
     Test if X is within range ( Y[1],Y[2] )

565  (Y[1]≤X)∧(X≤Y[2])                            X←D; Y←D1; 2=⍴Y
     Test if X is within range [ Y[1],Y[2] ]

566  0∧X                                                        X←B
     Zeroing all boolean values

567  (X×G)+Y×~G                                    X←D; Y←D; G←B
     Selection between X and Y depending on condition G
```

568 `(~⎕IO)+X` X←I
Changing an index origin dependent result to be as ⎕IO=1

569 `Y*~X` Y←D; X←B
Conditional change of elements of Y to one according to X

COMPARISON < ≤ = ≥ > ≠

570 `X≤Y` X←B; Y←B
X implies Y

571 `X>Y` X←B; Y←B
X but not Y

572 `(0≠X)×Y÷X+0=X` X←D; Y←D
Avoiding division by zero error (gets value zero)

573 `X≠Y` X←B; Y←B
Exclusive or

574 `X+Y×X=0` X←D; Y←D
Converting zeroes to Y

575 `Y=X` X←I; Y←I
Kronecker delta of X and Y (element of identity matrix)

RAVEL / CATENATE ,

576 `,(((ρX),Y)ρG),X` X←A1; Y←I0; G←A0
Catenating Y elements G before every element of X

577 `,X,((ρX),Y)ρG` X←A1; Y←I0; G←A
Catenating Y elements G after every element of X

578 `,Y,[⎕IO+.5]X` X←A1; Y←A1
Merging vectors X and Y alternately

579 `X,⎕TC[2],Y` X←A1; Y←A1
Separating variable length lines

580 `,X,[1.1]' '` X←C1
Spacing out text

581 `,X,[1.1]Y` X←A1; Y←A0
Inserting Y after each element of X

582 `(X,X)ρ1,Xρ0` X←I0
X×X identity matrix

583 `X,[.5+ρρX]-X` X←D
Array and its negative ('plus minus')

584 X←(ρX)ρA Δ A[G]←Y Δ A←,X X←A; Y←A; G←I
Temporary ravel of X for indexing with G

585 X←AρX Δ X[G]←Y Δ X←,X Δ A←ρX X←A; Y←A; G←I
Temporary ravel of X for indexing with G

586 X,[□IO-.1]'¯' X←C1
Underlining a string

587 X[;,1] X←A2
First column as a matrix

588 X,[.1]Y X←A1; Y←A1
Forming a two-row matrix

589 X,[1.1]Y X←A1; Y←A1
Forming a two-column matrix

590 ((((ρρX)-ρρY)ρ1),ρY)ρY X←A; Y←A
Increasing rank of Y to rank of X

591 ((0.5×ρX),2)ρX X←A1
Reshaping vector X into a two-column matrix

592 (ρX)ρ ... ,X X←A; ...←EXPRESSION
Handling array X temporarily as a vector

593 (Y,ρX)ρX X←A1; Y←I0
Forming a Y-row matrix with all rows alike (X)

594 ((ρX),1)ρX X←A1
Reshaping vector X into a one-column matrix

595 (1,ρX)ρX X←A1
Reshaping vector X into a one-row matrix

596 ρ,X X←A
Number of elements (also of a scalar)

597 Y,0ρX X←A; Y←A1
Joining sentences

598 X←0 2 1 2 5 8 0 4 5,□ X←D
Entering from terminal data exceeding input (printing) width

AXIS / INDEXING [

599 (ρX)[ρρX] X←A
Number of columns in array X

600 (ρX)[2] X←A2
Number of columns in matrix X

601 `(ρX)[1]` X←A2
Number of rows in matrix X

602 `Y[2+×X]` X←D; Y←A1
Choosing according to signum

603 `Y×1 ¯1[1+X]` Y←D; X←B
Conditional elementwise change of sign

604 `X[2×⎕IO]` X←A1
Selection depending on index origin

605 `' *'[⎕IO+X]` X←B
Indexing with boolean value X (plotting a curve)

606 `X[⎕IO+Y]` X←A1; Y←I
Indexing independent of index origin

607 `X[;1]` X←A2
First column as a vector

608 `X[]←0` X←D1
Zeroing a vector (without change of size)

609 `X[1]` X←A1
Selection depending on index origin

SHAPE / RESHAPE ρ

610 `(Y×ρX)ρX` X←A1; Y←I0
Duplicating vector X Y times

611 `X×(ρX)ρY` X←D; Y←D1
Multiplication of each row of X by vector Y

612 `ρρX` X←A
Rank of array X

613 `1ρρX` X←A2
Number of rows in matrix X

614 `(ρY)ρX` X←A1; Y←A
Array with shape of Y and X as its rows

615 `1ρX` X←A
Corner element of a (non-empty) array

616 `''ρX` X←A
Reshaping X into a scalar

617 `0ρX←` X←A
Output of an empty line

618 `0 80⍴0`
Forming an initially empty array to be expanded

\-\-\-

ARITHMETIC + − × ÷

619 `1+÷2+÷3+÷4+÷5+÷6 ...`
Continued fraction

620 `Y×÷X` — *X←D; Y←D*
Force 0÷0 into DOMAIN ERROR in division

621 `1 ¯1×X` — *X←D0*
Number and its negative ('plus minus')

622 `Y×X` — *X←D; Y←B*
Selecting elements satisfying condition Y, zeroing others

623 `X×¯1*Y` — *X←D; Y←B; ⍴X ←→ ⍴Y*
Conditional elementwise change of sign

624 `0×X` — *X←D*
Zero array of shape and size of X

625 `-⎕IO-X` — *X←I*
Changing an index origin dependent result to be as ⎕IO=0

626 `(⎕IO-1)+X` — *X←I*
Changing an index origin dependent argument to act as ⎕IO=1

627 `+X←` — *X←D*
Output of assigned numeric value

628 `⎕IO+X` — *X←I*
Changing an index origin dependent argument to act as ⎕IO=0

\-\-\-

MISCELLANEOUS

629 `*`
Syntax error to stop execution

630 `⎕←X←` — *X←A*
Output of assigned value

631 `⎕LX←⍞`
Setting latent expression

SYNONYM LIST

Adding X to each column of Y

```
193  1 1 2⍉X∘.+Y
192  1 2 1⍉Y∘.+X
```

Adding X to each row of Y

```
190  2 1 2⍉X∘.+Y
189  1 2 2⍉Y∘.+X
```

Arithmetic average (mean value)

```
365  (+/X)÷⍴X
332  (+/,X)÷1⌈⍴,X
```

Ascending cardinal numbers (ranking)

```
  1  ⌊.5×(⍋⍋X)+⌽⍋⍋⌽X
 13  ⍋⍋X
```

Centering text

```
323  Y↑((⌊-/.5×Y,⍴X)⍴' '),X
393  (-⌊.5×Y+⍴X)↑X
269  (-⌊0.5×+/∧\' '=⌽X)⌽X
248  (A-⌊0.5×(A←+/∧\⌽A)++/∧\A←' '=⌽X)⌽X
```

Changing index of an unfound element to zero

```
472  (1+⍴Y)|Y⍳X
541  (X∊Y)×Y⍳X
```

Conditional elementwise change of sign

```
603  Y×1 ¯1[1+X]
623  X×¯1*Y
```

Diagonal elements of matrix X

```
526  1 1⍉X
525  (1*⍴X)⍉X
```

Drop of Y first rows from matrix X

```
444  (Y,0)↓X
388  (2↑Y)↓X
```

Evaluating a two-row determinant

```
314  -/×/0 1⊖X
313  -/×⌿0 1⌽X
```

Expansion vector with zero after indices Y

```
 27  (⍴X)≥⍋(⍳⍴X),Y
538  ~(⍳(⍴Y)+⍴X)∊Y+⍳⍴Y
```

First ones in groups of ones

```
381  X>((-⍴⍴X)↑¯1)↓0,X
440  X>¯1↓0,X
```

Giving a default value for input

```
 97  1⍴(⍎⍞,',⍳0'),X
403  1↑⍞,X
```

Index of (first) maximum element of X

```
 23  ¯1↑⍋X
330  X⍳⌈/X
```

Index of (first) minimum element of X

```
 22  1↑⍋X
336  X⍳⌊/X
```

Indices of ones in logical vector X

```
 41  (+/X)↑⍒X
280  (+\X)⍳⍳+/X
506  X/⍳⍴X
```

Inverting a permutation

```
 37  ⍋X
553  A Δ A[X]←A Δ A←⍳⍴X
550  X⍳⍳⍴X
```

Locations of texts between and including quotes

```
287  A∨¯1↓0,A←2|+\X=''''
293  A∨¯1↓0,A←≠\X=''''
```

Locations of texts between quotes

```
288  A∧¯1↓0,A←2|+\X=''''
294  A∧¯1↓0,A←≠\X=''''
```

Merging (mesh)

```
482  A Δ A[(~G)/⍳⍴G]←Y  Δ  A←G\X
 12  (X,Y)[⍋⍋G]
 16  (Y,X)[⍋⍒G]
 31  A Δ A[⍋G]←A←Y,X
 11  (Y,X,Z,...)[⍋⍋G]
```

Number and its negative ('plus minus')

```
621  1 ¯1×X
583  X,[.5+⍴⍴X]-X
204  X∘.×1 ¯1
```

Number of columns in matrix X

```
600  (⍴X)[2]
410  ¯1↑⍴X
445  1↓⍴X
599  (⍴X)[⍴⍴X]
```

Number of elements (also of a scalar)

```
366  ×/⍴X
596  ⍴,X
```

Number of occurrences of scalar X in array Y

```
236  X+.=,Y
362  +/X=,Y
```

Number of rows in matrix X

```
601  (⍴X)[1]
411  1↑⍴X
```

```
613  1ρρX
446  ¯1↓ρX
```

Occurrence(s) of string X in string Y

```
178  (∧⌿(¯1+ιρX)⌽X∘.=Y)ι1
147  (Y[A∘.+¯1+ιρX]∧.=X)/A←(A=1↑X)/ιρA←(1-ρX)↓Y
219  ((-A)↓X∧.=(A,1+ρY)ρY)/ι(ρY)+1-A←ρX
```

Output of assigned value

```
630  ⎕←X←
627  +X←
```

Removing duplicate elements

```
501  ((XιX)=ιρX)/X
154  (1 1⍉<\X∘.=X)/X
505  A/ι9999 Δ A[X]←1 Δ A←9999ρ0
422  (¯1⌽1↓(X≠¯1⌽X),1)/X
```

Removing duplicate rows

```
 70  ((AιA)=ιρA←2⊥X∧.=⍉X)⌿X
208  (1 1⍉<\X∧.=⍉X)⌿X
327  (¯1⌽1↓(∨/X≠¯1⊖X),1)⌿X
206  ((AιA)=ιρA←⎕IO++⌿∧⍀X∨.≠⍉X)⌿X
```

Removing leading blanks

```
267  (+/∧\' '=X)↓X
299  (∨\' '≠X)/X
```

Removing trailing blanks

```
298  (⌽∨\⌽' '≠X)/X
 73  (1-(' '=X)⊥1)↓X
397  (¯1↑(' '≠X)/ιρX)ρX
428  (1-(⌽' '≠X)ι1)↓X
266  (-+/∧\' '=⌽X)↓X
```

Removing trailing blank columns

```
272  (⌽∨\⌽∨⌿' '≠X)/X
209  (⌽∨\⌽' '∨.≠X)/X
```

Replicate Y[i] X[i] times (for all i)

```
250  Y[+\(ι+/X)∊¯1↓1++\0,X]
251  ((X≠0)/Y)[+\¯1⌽(ι+/X)∊+\X]
253  Y[⎕IO++\(ι+/X)∊⎕IO++\X]
```

Representations of current date

```
107  A Δ A[(' '=A)/ιρA]←'/' Δ A←⍕100|1⌽3↑⎕TS
 65  A Δ A[5 8]←'-' Δ A←⍕1000⊥3↑⎕TS
104  A Δ A[(' '=A)/ιρA]←'.' Δ A←⍕⌽3↑⎕TS
 72  100⊥100|3↑⎕TS
```

Representations of current time

```
 64  A Δ A[3 6]←':' Δ A←⍕1000⊥3↑3↓⎕TS
105  (,(0 1↓3 0⍕100+3 1ρ12 0 0|3↑3↓⎕TS),':: '),'AP'[1+12≤⎕TS[4]],'M'
```

Reshaping non-empty lower-rank array X into a matrix

```
392  (1⌈¯2↑ρX)ρX
402  (¯2↑1 1,ρX)ρX
```

Reshaping vector X into a one-column matrix

```
203  X∘.+,0
534  (⌽1,ρX)ρX
594  ((ρX),1)ρX
```

Selection depending on index origin

```
604  X[2×⎕IO]
609  X[1]
```

Sorting rows of matrix X into ascending order

```
  9  (ρX)ρ(,X)[A[⍋(,⍉(⌽ρX)ρι1↑ρX)[A←⍋,X]]]
  8  (ρX)ρ(,X)[⎕IO+A[⍋⌊A÷¯1↑ρX]]  Δ  A←(⍋,X)-⎕IO
```

Spacing out text

```
580  ,X,[1.1]' '
490  ((2×ρX)ρ1 0)\X
```

Temporary ravel of X for indexing with G

```
585  X←A⍴X Δ X[G]←Y Δ X←,X Δ A←⍴X
584  X←(⍴X)⍴A Δ A[G]←Y Δ A←,X
```

Test for symmetricity of matrix X

```
 86  ⍎⍎'1','↑↓'[⎕IO+∧/(⍴X)=⌽⍴X],'''0~0∊X=⍉X'''
520  ~0∊X=⍉X
```

Test if all elements of vector X are equal

```
358  ∧/X=X[1]
343  ∧/X=1⌽X
340  0=(⍴X)|+/X
159  ∨/∧/0 1∘.=X
324  ∧/X=1↑X
315  (∧/X)∨~∨/X
311  (⌈/X)=⌊/X
317  ∧/X÷∨/X
352  ≠/0 1∊X
316  (∧/X)=∨/X
347  ⍲/0 1∊X
215  X∧.=∧/X
214  X∧.=∨/X
341  ∧/X/1⌽X
354  ∧/⎕IO=X⍳X
349  ~∧/X∊~X
```

Test if arrays of equal shape are identical

```
357  ∧/,X=Y
544  ~0∊X=Y
```

Test if numeric

```
400  0∊1↑0⍴X
486  0∊0\0⍴X
```

Test if X is a permutation vector

```
 20  X[⍋X]∧.=⍳⍴X
158  ∧/1=+/X∘.=⍳⍴X
346  ∧/(⍳⍴X)∊X
```

Value of polynomial with coefficients Y at point X

```
227  (X*¯1+⍳⍴Y)+.×⌽Y
 83  X⊥Y
 69  (X∘.+,0)⊥Y
```

Value of Taylor series with coefficients Y at point X

```
137  +/Y×(X*A)÷!A←¯1+⍳⍴Y
281  +/Y××\1,X÷⍳¯1+⍴Y
```

Vectors as matrices in catenation

```
273  X,[⎕IO-(⍲\2⍴∧/2>(⍴⍴X),⍴⍴Y)/.5 0]Y
274  X,[⎕IO+(⍲\2⍴∧/2>(⍴⍴X),⍴⍴Y)/.5 1]Y
```

X×X identity matrix

```
197  (⍳X)∘.=⍳X
582  (X,X)⍴1,X⍴0
```

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